Environmental Impact Analysis Process

ENVIRONMENTAL REVIEW

STARLAB SITE
ON ANTIGUA

7 SEPTEMBER 1990

DEPARTMENT OF THE AIR FORCE

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
07091990	N/A	-

Title and Subtitle Environmental Impact Analysis Process Environmental Review Starlab Site On Antigua	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) U.S. Air Force	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) sponsoring agency and address	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
70

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ACRONYMS AND ABBREVATIONS

AFOSH	Air Force Occupational Safety and Health
AFR	Air Force Regulation
AMOS	Air Force Maui Optical Station
ANSI	American National Standards Institute
ATP	acquisition, tracking, and pointing
CFR	Code of Federal Regulations
CITES	Convention of International Trade in Endangered Species of Flora and Fauna
Cm	centimeter
DOD	U.S. Department of Defense
EA	Environmental Assessment
ETR	Eastern Test Range
IRPA	International Radiation Protection Association
J	Joules
Km	kilometer
LMSC	Lockheed Missile and Space Company
M	meter
MPE	Maximum permissible exposure
MW	milliwatt
NASA	National Aeronautics and Space Administration
PEP	Payload Experiment Package
POCC	Payload Operations Control Center
S	seconds
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
STO	Space Test Object
SWAT	Short Wave Adaptive Technology
USAF	U.S. AIR FORCE
USASDC	U.S. Army Strategic Defense Command
USFWS	U.S. Fish and Wildlife Service
VOA	Voice of America

SUMMARY

This Environmental Review has been prepared in accordance with the Department of Defense Directive 6050.7 and Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions), as implemented by Air Force Regulation 19-3 (Environmental Impact Analysis Process Overseas). The Proposed action evaluated in this Environmental Review is to construct and operate a ground calibration site at Cotar Hill on Ascension Island, a dependency of the British Island of St. Helena. The ground calibration site would be used during a portion of the British Island of St. Helena. The ground calibration site would be used during a portion of the Starlab Program experiments that have been described in a previous Environmental Assessment (USAF 1990). The purpose of these engagements and experiments is to advance the research program of the Strategic Defense Initiative Organization (SDIO), particularly that involving the acquisition, tracking, and pointing capabilities of Electro-optical and laser systems.

The proposed ground calibration experiments would use the green and red Starlab lasers on the Space Shuttle to locate and actively scan a site on Ascension Island. The experiments would demonstrate tracking and pointing accuracy of the laser system before conducting other Starlab experiment.

The most significant issue addresses in this Environmental Review is the potential exposure of people and/or wildlife to laser beams. The USAF has prepared extensive analyses of potential laser effects, which provide critical input to the evaluation in this Environmental Review. Detailed safety analyses of the effects of laser systems conducted by the USAF and independent calculators done in preparing the Starlab Program EA (USAF 1990) indicate that no significant impact to humans or wildlife would occur from exposure to lasers because the probability of people or wildlife seeing one plus is so small (1x 10-9) and the duration of exposure would be so short (25 nanoseconds).

Other issues that are discussed and evaluated in this document are the potential environmental impacts of constructing and operating the ground calibration site on land use, ecological resources, endangered and threatened species, and cultural resources. Construction and Operation impacts of a ground calibration site on Antigua have little potential for causing adverse environmental impacts. The proposed Telemetry site is already disturbed and is adjacent to existing U.S. Air Force facilities.

Archaeological and historic cultural remains are known to be present on the proposed site. Impacts to these resources are expected to be minimal because the amount of excavation and earth movement would be limited. Mitigative measures that would be implemented to ensure that no significant impacts to archaeological and historic resources occur include (1) laying out the exact location of site structures and equipment in consultation with a qualified archaeologist to avoid disturbing important remains to the extent practicable, (2) having a qualified archaeologist on site during site preparation, construction, and dismantling to monitor any archaeological or historic remains that are uncovered,

(3) Undertaking salvage work, if necessary, to document or possibly salvage any important remains, and (4) consult with the Antiguan government and local experts to ensure compliance with relevant local laws and regulations. ETR personnel would consult with local officials and experts to identify any additional local concerns before iniating any construction activities.

1. INTRODUCTION

This environmental Review has been prepared to identify and evaluate potential environmental issues associated with the proposed construction and operation of a ground calibration site on the Island of Antigua in the Caribbean. Antigua, together with neighboring Barbuda and Redondo, form the State of Antigua, which was granted independence "in association with Great Britain" in 1967. The proposed site would be used during a series of laser experiments that are part of the Starlab Program and are described in a separate Environmental Assessment (USAF 1990a).

1.1 PRUPOSE AND NEED

Former President Reagan announced on March 23, 1983, that he was directing a "comprehensive and intensive effort to define a long term research and development program to begin to achieve our ultimate goal of eliminating the threat posed by strategic nuclear missiles." To implement this directive, the President created the Strategic Defense Initiative Organization (SDIO), which was charted to oversee activities related to the Strategic Defense Initiative (SDI).

The Starlab program is an SDI activity that consists of a dedicated Space Shuttle mission having the objectives of demonstrating "proof of concepts" for several space based defense experiments and new concepts for performing strategic space experiments using the Space Shuttle/Spacelab capability. Under a Memorandum of Agreement between the National Aeronautics and Space Administration (NASA) and DOD, NASA will provide launch services for the Space Shuttle and overall Starlab mission coordination and support. SDIO is the DOD sponsor for the Starlab program (NASA and DOD 1989), AND THE u.s. Air Force (USAF) is responsible for developing the Starlab payload and conducting the experiments. The U.S. Army Strategic Defense Command (USASDC) is responsible for the ground launch vehicles (i.e., Project Starbird) associated with Starlab. The Eastern Test Range (ETR) is responsible for preparing and operating the ground calibration sites.

The Starlab program includes a serious of experiments that use Electro-optical and laser systems aboard the Space Shuttle and on ground. These experiments are designed to (1) demonstrate acquisition, tracking, and pointing (ATP) of laser systems; (2) collect plume and background information to narrow phenomenology uncertainties; and (3) provide a basis for making an informed decision on the design of a weapon ATP system. Starlab includes experiments that use laser beams propagated by equipment from the orbiter and to and from the ground. The laser experiments involve (1) calibration of the Electro-optical systems, using objects deployed from the orbiter (i.e., space test objects) and scoreboards at ground calibration sites on Antique in the Caribbean and Ascension Island in the Atlantic Ocean; (2) ATP activities associated with Starbird test vehicle launches from Wake Island in the Pacific Ocean and Cape Canaveral, Florida; (3) participation in Short Wave Adaptive Technology (SWAT) experiments at the Air Force Maui Optical Station (AMOS), Hawaii; and (4) wave front control experiments. In addition to these laser experiments, background data on the composition of visible and other spectral radiation from planets and stars would be collected during the Starlab mission to assist in calibrating the Electro-optical systems.

1-2 SCOPE

This Environmental Review evaluates potential environmental effects of developing and operating a ground calibration site for Starlab experiments on Ascension Island, a dependency of the British Island of St. Helena. The Environmental Review addresses site specific activities on Ascension Island that are not addressed in the Environmental Assessment (EA) on the Starlab Program (USAF 1990). This document has been prepared following DOD Directive 6050.7 and Executive Order 12114 (environmental Effects Abroad of Major Federal Actions), as implemented by Air Force Regulation (AFR) 19-3 (Environmental Impact Analysis Process Overseas). Executive Order 12114 is applicable because the Starlab programs involve activities in a foreign country and over international waters. The Purpose of an environment review (AFR 19-3, 6) is to identify the important issues of a proposed action in a foreign country and to "review what, if any, consideration has been or can be given to the environment by the United States and by any foreign government involved in taking the action."

A major issue addressed in this document and in Starlab Program EA is the potential exposure of people and/or wildlife to laser light. The USAF has prepared extensive analyses of potential laser effects [Payload Experiment Package (PEP)-20 (LMSC 1989)], which provide critical input to the evaluation in this Environmental Review to verify conclusions reached in the PEP-20 analysis. Other issues that are evaluated include the potential impacts of constructing and operating Starlab facilities on land use, ecological resources, endangered and threatened species, and cultural resources.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 DESCRIPTION OF THE PROPOSED ACTION

The proposed action would use the Space Shuttle (Fig. 1) to conduct and complete SDI experiments within a scheduled 7- day mission in the second quarter of 1992. These experiments would use Spacelab hardware located in the obiter bay to interact with ground sites, missiles in flight, and space test objects (STOs) deployed from the orbiter.

The experiments are primarily designed to demonstrate the feasibility of using space based, Electro-optical and laser systems for the acquisition, subsequent tracking, and marking of missiles from space. Some of the proposed experiments use the Electro-optical system in a passive fashion, while others use it in a mix of active and passive modes. A passive experiment uses the Electro-optical system camera to capture images with available light (e.g., the calibration and background experiment described in Sect.2.1.3.1 of the Starlab EA (USAF 1990a). An active segment of an experiment uses lasers to provide the necessary illumination [e.g., acquiring and tracking a ground launched Starbird vehicle and its plume (Sect. 2.1.3.4 of the Starlab EA (USAF 1990a)]. Approximately 20 separate events or engagements are scheduled for Starlab as parts of six experiments.

Figure 2 shows a typical earth orbital path for the orbiter and indicates the ground sites involved in the experiments. These sites include Wake Island, Cape Canaveral, and the Hawaiian Island of Maui, as well as Antigua and Ascension Island.

2.1.1 General Description of the Starlab

Figure 1 shows the orbiter with its bay doors open and the experimental Starlab payload exposed. The major components of the payload (Fig.3) include the Spacelab module and the Spacelab pallet. As shown in Fig. 3, the crew via an umbilical connection (i.e., egress tunnel) accesses the Spacelab module, located forward of the pallet. Primary tasks of the payload specialists include observing and evaluating the Starlab experiments and being ready to correct problems with the equipment should arise. In this capacity, the specialist will serve as systems safety officer by having the ability to shut down any experiment or modify experimental operating parameters. The specialist will observe and control the experiments through devices contained in the experiment control racks (Fig. 3).

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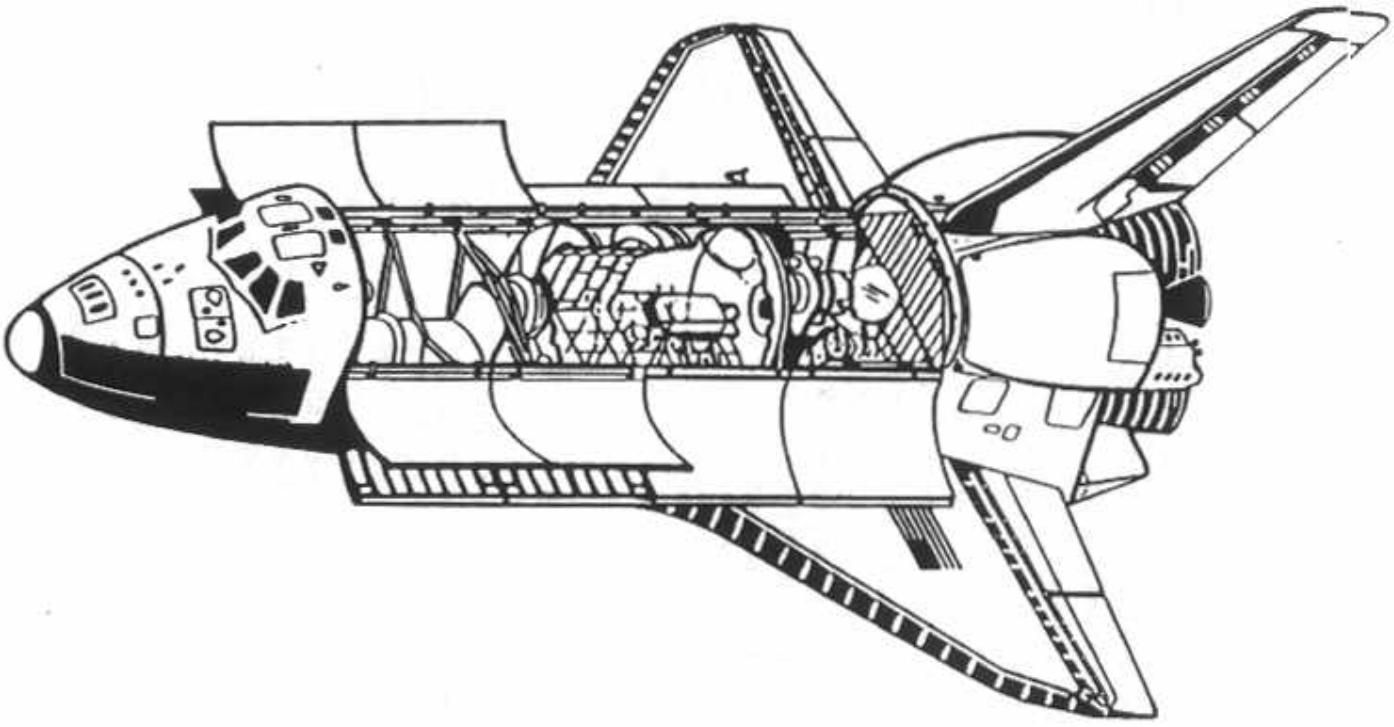

Fig. 2-1. The Space Shuttle (Orbiter).

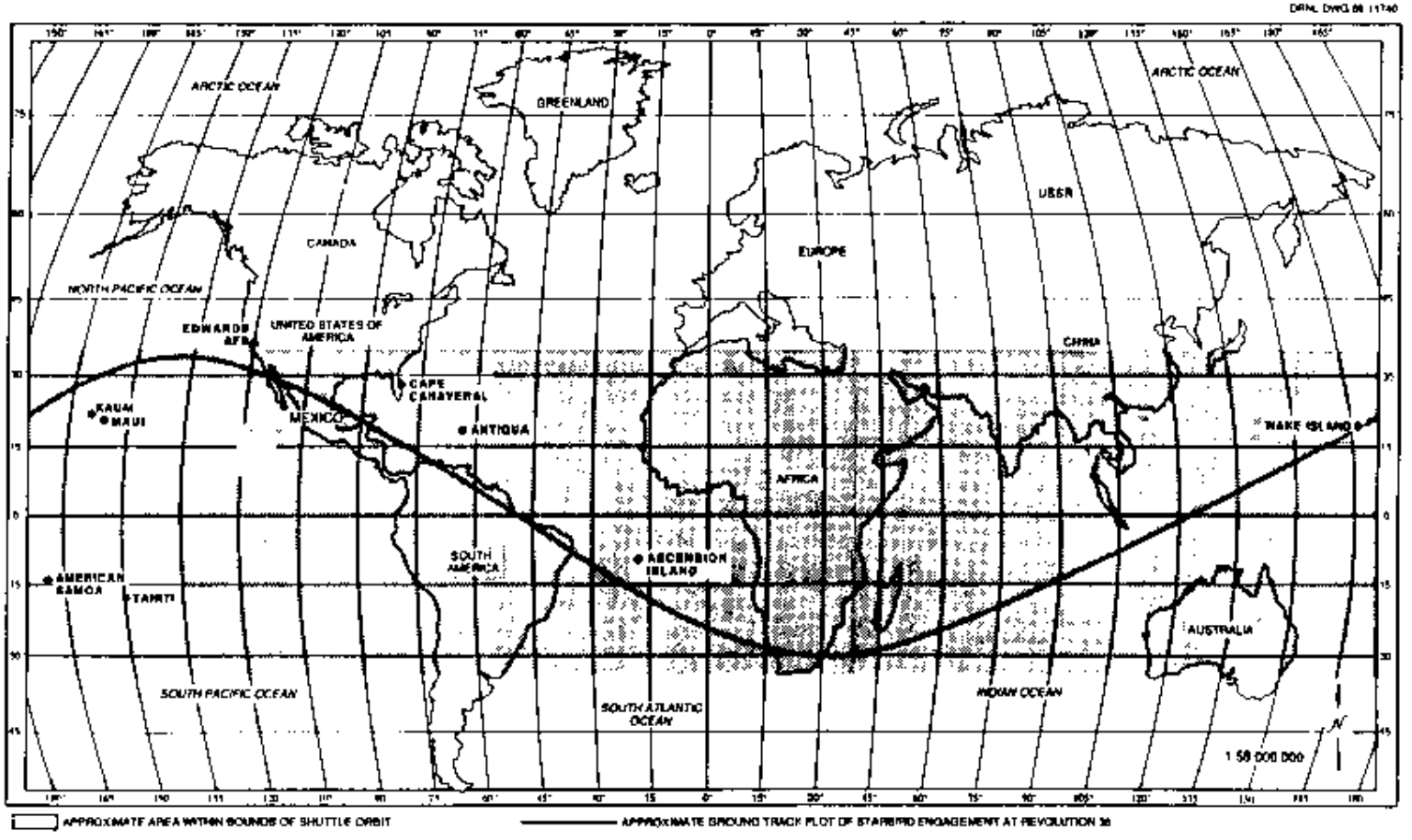

Fig. 2-2. Typical orbit and Starlab ground sites.

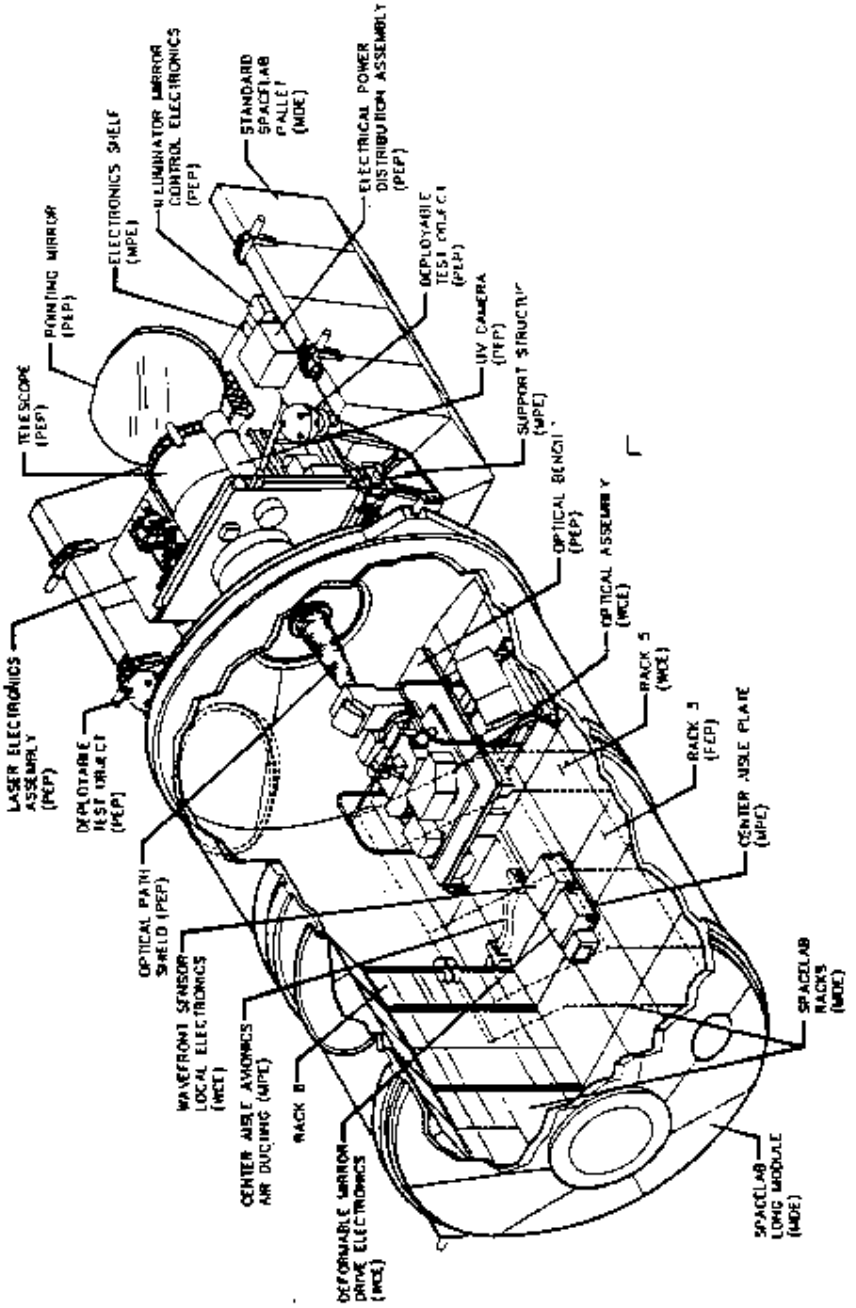

Fig. 2-3. The Starlab payload.

The module will contain the optical bench that houses the maker laser and associated electronics (Fig. 3). The marker laser will be used to mark experimental objects once they have been identified and are being tracked. The Spacelab module and pallet are Electro-optically linked and will function in a coordinated fashion during the experiments, with the marker beam traveling through the optical viewpoint into the Spacelab pallet.

Major elements contained within the Spacelab pallet (Fig. 3) will be the illuminator laser; a 31.5-in. (80-cm) telescope; ultraviolet, acquisition video, and infrared cameras; a 5-ft (1.5-m) pointing mirror; and STOs. The Spacelab pallet will be open to space. The marker laser beam passes through the optical viewpoint, is routed through the telescope, and is subsequently reflected by the pointing mirror to its destination. All other optical beams and images are reflected by the pointing mirror. The cameras are used for initial acquisition and during the passive portions of experiments to assist in identifying experimental test objects under a variety of conditions. The illuminator laser will be used in active mode to illuminate and track experimental objects.

The two types of lasers that will be transmitted from the orbiter are the “marker” (red) and “illuminator” (green) lasers. A back up to the illuminator laser will be provided. . Some general characteristics of the lasers are given in Table 1. A more detailed technical description of the lasers is provided in Appendix E of the Starlab Program EA (USAF 1990).

2.1.2 Ground Operations

Ground operations include (1) experiment command, control, and configuration; (2) experiment performance assessment; (3) data analyses; and (4) dedicated planning. Operations during the mission will be controlled from and coordinated with the NASA Marshall Space Flight facility at Huntsville, Alabama. Ground control facilities will be located at Cape Canaveral and Wake Island for the Starbird engagements and at Maui for the SWAT experiments. These control facilities will be in continuo communication with NASA throughout the 7-day mission.

2.1.3 Starlab Experiments

The experiments and engagements included in the proposed action (Table 2) can be grouped for discussion as passive and active experiments. Passive experiments do not involve lasers and are used to gather background data and calibrate equipment. Active experiments use lasers include the Ground Calibration engagements. Experiments other than ground calibration are described in detail in the starlab Program EA (USAF 1990a).

Table 2-1. Characteristics of lasers to be used in Starlab experiments[a]

Characteristic	On the shuttle		At Maui[b]	
	Illuminator	Marker	Beacon	Uplink
Wavelength	0.5321 μm	0.6328 μm	0.4880 μm	0.5145 μm
Color	green	red	blue	green
Beam energy (at laser aperture)	220 mJ/pulse	<5 mW	4 W	5 mW
Mode of operation	pulsed	continuous	continuous	continuous
Maximum permissible exposure to the eye[c]	3.34×10^{-7} J/cm^2	6.36×10^{-4} J/cm^2 (for 0.25 sec)	6.36×10^{-4} J/cm^2 (for 0.25 sec)	6.36×10^{-4} J/cm^2 (for 0.25 sec)

[a]Table E-1 (Appendix E) presents more detailed information on laser characteristics.
[b]Maui is the location of the Air Force Maui Optical Station (AMOS), the ground location for the Short Wave Adaptive Technology (SWAT) experiments.
[c]International Radiation Protection Association (1985).

Table 2-2. Summary of proposed Starlab experiments/engagements

Experiment/engagement	Ground location(s)	Action(s)
Background experiment	Non-specific	Collect and analyze ultraviolet and and infrared data by passively scanning the earth's surface.
Planets and stars background experiment	None	Passively observe the stars and planets from the orbiter to calibrate the electro-optical system.
Space test objects and rapid retargeting experiment	None	Boresight the illuminator laser to the marker laser; demonstrate ability to change from tracking one STO to acquiring and tracking a second STO.
Ground calibration engagements	1. Ascension Island 2. Antigua	Locate and actively scan sites with red and green lasers, which are then reflected back to the orbiter.
Starbird engagements	1. Wake Island, Peacock Point 2. Cape Canaveral, Launch Complex 20	Actively identify and track Starbird vehicles and plumes from the orbiter using green and red lasers.
Short Wave Adaptive Technology experiment	Air Force Maui Optical Station (AMOS)	Actively link the orbiter and AMOS with blue and green lasers from AMOS and a red laser from the orbiter.

2.1.4 Ground Calibration Engagements

Specific ground calibration locations will be established so that the orbiting Starlab can calibrate its optical control system in flight before subsequent Starbird engagements involving the launching of Vehicles from Cape Canaveral and Wake Island. Ground Calibration sites were selected on Antigua and Ascension Island. The preferred Ascension Island site is on top of the Cotar Hill site. The Antigua ground calibration site is evaluated in a separate in a separate Environmental Review document. A discussion of the selection process for these sites is provided in Sect. 2.2.2

The USAF ETR is responsible for establishing each of the Calibration sites. Preparation of three concrete pads [15x20 ft (4.6 x 6.1 m), 12 x 22 ft (3.7x 6.7 m), and 10 x 7 ft (3 x 2.1 m)] is the only construction that will be required to mount contractor furnished equipment. Existing ETR buildings will house NASA communications equipment and contractor equipment for remotely controlling the scoreboard area. Cabling between equipment locations is required.

The general layout is shown in Fig 5. The site will consist of a scoreboard area and an operations center. The boundary markers around the calibration site will consist of temporary signs and manned roadblocks that will be installed immediately before each Starlab engagement. This additional precaution will be taken despite the conclusions that eye damage could not occur even with binoculars (Sect 4.2.1). No personnel will be at the scoreboard area during an engagement.

A fence to prevent personnel form entering the area during the engagement and to provide security for the installed equipment will surround the Scoreboard area. The equipment within the fence simulates various stages of a Starbird vehicle for the calibration exercise. The layout of equipment within the fenced area is shown in Fig.6. The scoreboard itself represents the payload on a Starbird vehicle. The Scoreboard has a 5 x 8-ft (1.5 X 2.4 m) reflective surface mounted on a structure that permits it to be tilted to face the orbiting Starlab. The structure will be bolted to a concrete pad and will be aligned with the Starlab ground track. A set of beacon lights consisting of 15, 1000-watt lamps simulates the third and fourth stag e plumes of a Starbird vehicle. These lights provide a 140-degree x 10-degree wedge of light and require a 60-kw diesel generator. A pair of retroflectors (i.e., a special type of prism reflector) oriented 60 degrees apart will be mounted on the scoreboard. A video camera records the mark laser beam as it impinges on the scoreboard.

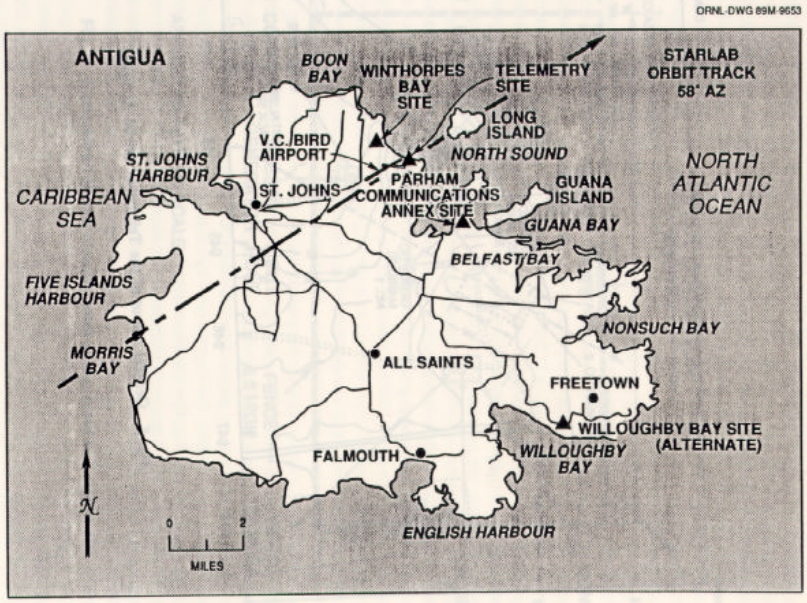

Fig. 4. Location of sites on Antigua.

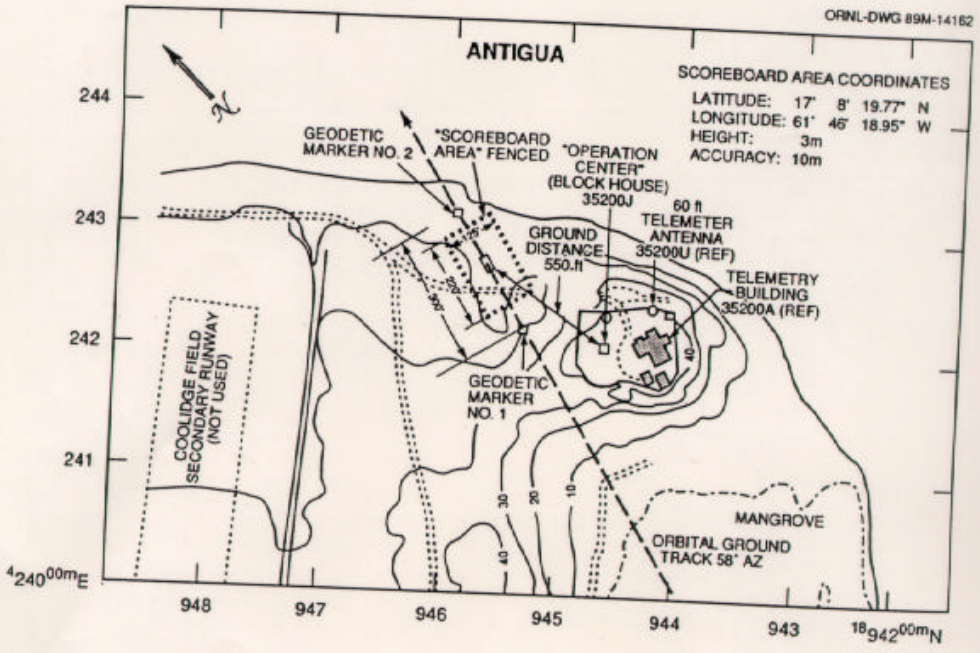

Fig. 5. General layout of the Telemetry site on Antigua.

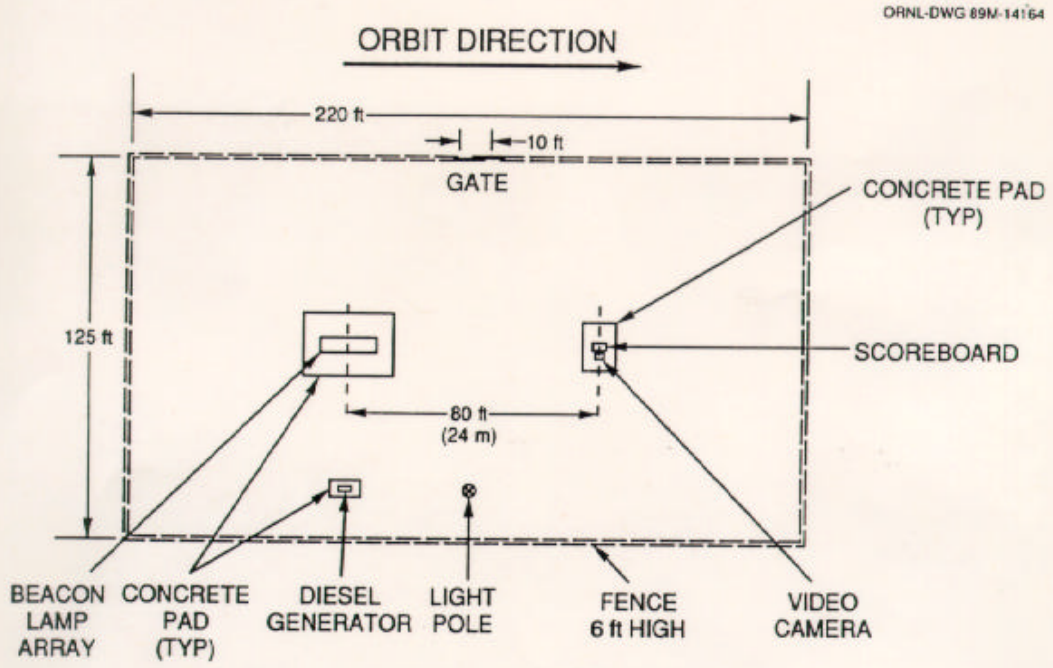

Fig. 6. Generalized layout of equipment at a ground calibration site.

The operations building will be the manned control center for operation of ground equipment during the Starlab calibration engagements. This control center positions stations for overall site control, beacon lamp control, video camera monitoring, and communications existing building at the Cotar Hill site on Ascension Island will be used to house the operations control center.

Contractor and NASA personnel will set up and check out their equipment at the two calibration sites. Contractor personnel will operate the equipment during the engagement. ETR will provide housing, meals, and transportation on Ascension Island.

Preparation of the calibration site will be ignited six months before the engagement. ETR will perform ground construction work and prepare the existing building for use as the operations control center. Four months before the mission, the equipment for the experiment will be transported to Ascension Island by air and then by truce to the calibration site. Three months before the mission, NASA and contract personnel will begin to set up and check out the equipment. Checks of the communication link between the calibration site, NASA's POCC will occur during the second month before the mission, and a stimulated engagement will be performed during the month immediately preceding the mission. After the completion of the Starlab engagement, the equipment will be returned to NASA and the contractors, and ETR will restore the site to its original condition.

Because the length of the Starlab mission will be seven days, the calibration site must be in operational status for six days, with up to three engagements scheduled. Engagements will normally occur between 0100 and 0400 local time.

Before an engagement, site personnel will report weather conditions and equipment readiness to the POCC. Approximately five people will be presents at the site during the engagements. Thirty minutes before the engagements, all systems will be checked and the status reported to NASA at Huntsville, Alabama. Ten minutes before the engagement, clearance from the POCC will be given. The payload specialist aboard the shuttle will use the acquisition camera to innate the engagement by locating the high intensity lights at the ground calibration site (see Fig 6). The illuminator laser will then be turned on for active tracking of the target. Once tracking is demonstrated, the marker laser will be turned on to demonstrate pointing accuracy and for beam evaluation purposes. Thee exercises will serve to verify Starlab system operation before Starbird engagements. Each engagement will last approximately 4.5 min.

2.1.5 Mitigation Measures

The proposed action includes the following mitigation measure to ensure that no significant impacts will occur:

1. All facilities constructed at the ground calibration site on Antigua will be removed after the mission is completed, and the site will be restored to its original condition. All trash will be removed from the area and properly disposed.

2. Access restrictions will me minimized at the ground calibration site, allowing roads to be open to all traffic except immediately before, during, and immediately after the engagements. ETR will provide adequate roadblocks and warning signs near the ground calibration site to keep people away from any areas where accidental exposure to laser beams could occur.

3. Before any site preparation activities are ignited, ETR will consult with the Antiguan government concerning protected species, cultural resources, and other resources that may be of concern.

4. ETR will consult with Antiguan government officials and other appropriate local authorities to ensure that no aircraft operations occur during the ground calibration engagements.

5. ETR will keep construction workers and activities away from the shoreline area to avoid disturbing sensitive mangrove habitat.

6. To avoid any disorientation of sea turtle hatchlings on nearby beaches (e.g., Long Island), lights of appropriate wavelengths will be used at the calibration sight should the experiment occur during the sea turtle nesting season.

7. To minimize potential disturbance of any potentially significant archaeological and historical remains, the exact location of the calibration pad and associated structures (e.g., fence posts) will be delineated in consultation with a qualified archaeologist knowledgeable about Antiguan cultural resources.

8. During site preparation, construction, and dismantling operations, a trained archaeologist will be on the site to monitor any archaeological and historical remains found and to determine if any more complete archaeological excavation or documentation will be needed.

9. If potentially significant archaeological or historical remains are identified by the onsite archaeologist as being in jeopardy of being disturbed by site activities, further archaeological work will be conducted to document and/or salvage any significant remains that are found, or the remains that are found, or the remains will be protected in place.

2.2 ALTERNATIVES TO THE PROPOSED ACTION

This section discusses the no-action alternative and alternatives to the proposed action, focusing on alternative ground locations where impacts could occur.

2.2.1 No-Action Alternative

Under the no-action alternative, the Starlab experiments would not be conducted. The no-action alternative would not satisfy the DOD need for research and experimentation to support the SDI program. If the Starlab program were not implemented, the environmental impacts resulting from the proposed construction and operation of the ground calibration site on Ascension Island would not occur, and alternative means of achieving program goals would need to be explored. In summary, pursuing this type of alternative would not meet Starlab Program requirements and scientific objectives.

2.2.2 Alternative Ground Calibration Locations

The USAF when considering the objectives of the Starlab Program identified a number of potential sites. Screening of site locations was first done based on technical criteria. Environmental considerations were factored into the process during the selection of specific locations. To meet the maximum number of scientific objectives, the site selection process was governed by three primary technical factors: (1) orbit, (2) experiment function, scheduling, and (3) geographic location. Orbit criteria were determined by meeting the launch and landing restrictions orbit ephemeris (i.e., known position of a body at regular intervals), and the desired timing for various experiments. Meeting the objectives of the experiment ensures that the maximum amount of scientific information wold be obtained from each activity. Specific geographic sites were selected because they fell within the view of the Starlab and because they could be used on repeat orbits to collect additional data and provide data replication. Application of these technical criteria resulted in the identification of four potential locations for ground calibration sites; namely, Roi Namura, Maui, Antigua, and Ascension Island.

The site screening process resulted in the selection of Ascension Island and Antigua as ground calibration sites. These sites were selected using the following criteria: (1) the field of view must fall within certain limits; (2) the sites must be sufficiently remote that if a laser tracking malfunction should occur, a stray laser beam would not pass over a populated area or sensitive wildlife area; (3) bright lights should not be present near the site or, if present, bright lights could be turned off before and during the starlab engagement; (4) the site must be owned or leased by either the USAF or another U.S. government agency and must be away from public view; (5) the area selected must be sufficiently large to allow an outer boundary of 3000 x 7600ft (900 x 2300 m) (fig. 7) to be created that will exclude any areas containing private dwellings; and (6) tight control of access into the area must be possible. A further evaluation, including analysis of potential environmental impacts, was conducted to identify specific locations on Ascension Island (Sect. 2.2.3).

2.2.3 Alternative sites on Antigua

Four alternative locations for ground calibration facilities were identified and evaluated during site visits. Two of these sites, the ETR Telemetry site and the Willoughby Bay site (Fig. 4), are evaluated in detail this environmental review. The Telemetry site is the preferred location, and the Wiloughby Bay site is an acceptable alternative. The Winthrope's Bay and Parham Communications Annex locations, which are briefly described in the following paragraphs, were evaluated during the site visit and eliminated from further consideration. A summary comparison of the Telemetry and Willoughby Bay sites is also provided.

2.2.3.1 Winthorpe's Bay Site

The Winthorpes Bay site is on USAF-controlled property that is close to a local shoreline fishlike fishing site, and the Beachcomber Hotel [approximately 0.4-mile (0.6 km) from the proposed target]

. The ground at this site, which is near the ETR Telemetry Station, has been leveled, and a public road runs along one side of the area. A communication tower is located on the site. The area is predominantly covered with grasses but has scattered individual plants or small patches of acacia. Cattle apparently graze it. Although this site could be developed in an environmentally acceptable manner, given its already disturbed condition, it has been eliminated from further consideration because of its proximity to areas used by the public, a nearby motel, and a communications tower.

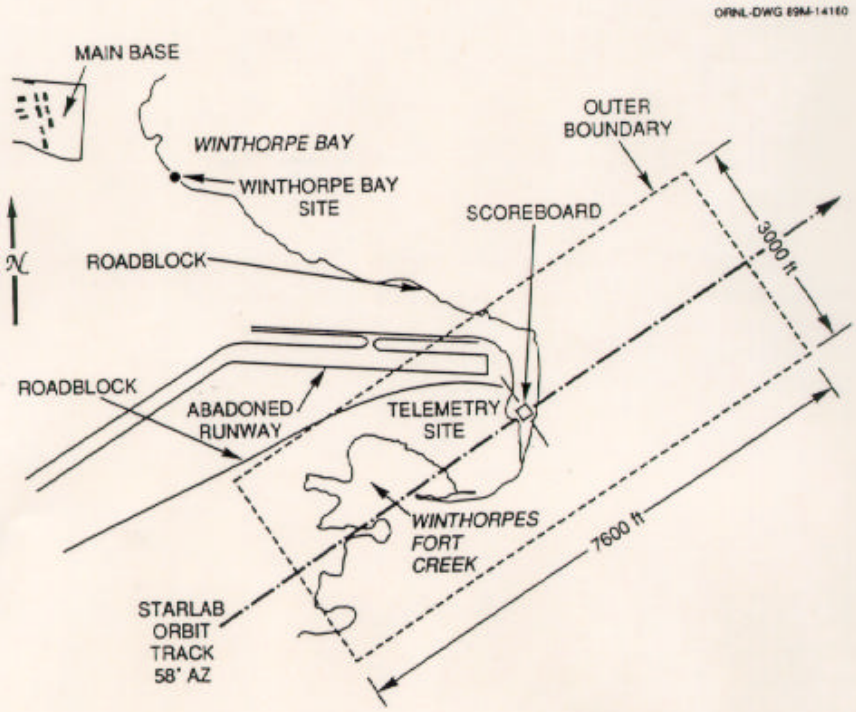

Fig. 7. Boundaries of the Telemetry site on Antigua.

2.2.3.2 Parham Communications Annex Site

The Paraham Communications Annex site is on the northeast side of Antigua, southeast of the USAF Station. This area has been previously disturbed and does not support any unique features. The site supports a high-power antenna field located on it and is close to public facilities, including the island desalination plant and an Antiguan Government military installation. These existing uses on or near the site have eliminated the site from further consideration.

2.2.3.3 Comparison of the Telemetry and Willoughby Bay Sites

A detailed description of the existing environment and an evaluation of environmental impacts of developing the Telemetry and Willoughby Bay sites are provided in Sects. 3. In addition, 4 of this Environmental Review. The major similitarties and difference between these two sites, however, can be summarized as follows: (1) The Telemetry site is on USAF property, while the Willoughby Bay Site is on the land leased by the voice of America (VOA). (2) The Telemetry site has already been disturbed and, therefore, use of the site would not involve disturbance to any natural vegetation or wildlife habitat. Development of the Willoughby Bay Site would require removal of some natural second growth vegetation and wildlife habitat, including possible hummingbird habitat. (3) Access to the USAF communications facilities is much better at the Telemetry site because of its proximity to the existing telemetry facilities. (4) The Telemetry site is only short distances from the USAF station and is readily accessible by roads. (5) Both sites are likely to have archaeological and historic remains present, and surveys of either site would be needed before either was developed. (6) The telemetry site is closer to population centers than is the Willoughby bay Site, (7) Mangroves, a species of local concern, are present along the edge of the Telemetry site and need to be protected from inadvertent disturbance during any development of the site. (8) No aquatic resources would be affected at either site. The major advantages of the Telemetry site are its proximity to ETR facilities, its location on USAF property and the fact that no natural vegetation and wildlife habitat would be affected by its use as a Starlab site. With the mitigation recommended in Sect 2.2.5, development of either site, as a ground calibration site is considered environmentally acceptable.

3. AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This section describes the environment that could be affected by the proposed construction and operation of the ground calibration site on Antigua. The resources that are evaluated include land use, terrestrial and aquatic ecological resources, threatened and endangered species, and cultural resources. A general description of other resources (e.g., air quality) is given as needed to provide adequate background for understanding the evaluation of impacts in Section 4 of this environmental Review.

3.2 PHYSICAL SETTINGS

Antigua is a hilly coral limestone island, the surface features of which are shown in Fig. 8. Ridges, isolated hills, and stretches of plain suggest a complex geological past. Almost all of the soils of Antigua are poorly drained. During the rainy season, the soils rapidly become waterlogged, but they quickly dry out and develop deep vertical cracks during the dry season.

The climate is mild all year, with the warmest daily mean temperatures [83 to 86 degrees Fahrenheit (28 to 30 degree Celsius)] occurring in August and September, and cooler temperatures [73 to 76 degrees Fahrenheit (23 to 24 degree Celsius)] in January and February (Holland and Williams 1978). The rainy season usually begins about the middle of August and lasts until December; the dry season is sometimes interrupted by light rains I June (Holland and Williams 1978). Mean annual rainfall for the Entire Island from 1874 to 1960 was about 43 inches. (109 cm), with a range of 25 to 74 in. (64 to 188 cm) (Harris 1965).

Irregular rainfall occurs throughout the island and causes wide fluctuations in the flow of the island streams. All of the streams become swollen torrents after heavy rains, but for much of the year; they exist only as disconnected stagnant pools. The only perennial watercourses are Bindles and Collins streams, which drain the central plain (Fig.8).

3.3 LAND USE

Land in Antigua is primarily rural and agrarian in nature. When it was first settled, the island was used for growing tobacco. By the end of the seventeenth century, however, growth of tobacco as the main crop had been replaced totally by sugar cane, which remained the basis of the economy until well into the second half of the 29th century. Land use has remained relatively stable since Antigua became a Crown Colony in 1956 (Statistical Office 1985). Primary land uses are unproductive or unclassified lands (27 % of total land use), agriculture (25% of total land use), arable lands not currently under cultivation (20% of toall land use), forest/conservation and parks (17% of total land use), settlements (11% of total land use), and industry and commerce (less than 1% of total land use) (Statistical Office 1985). The primary agriculture uses of land are livestock (57% of all agricultural land) and root crops (approximately 38% of all agricultural land). St. Johns is the capitol of Antigua, with a 1982 population of approximately 36,000 (Europe Publications 1988). Major transportation access to the Island is via the V.C Bird International Airport, located approximately 4.5 mi. (7.2 kn.) east of St. Johns.

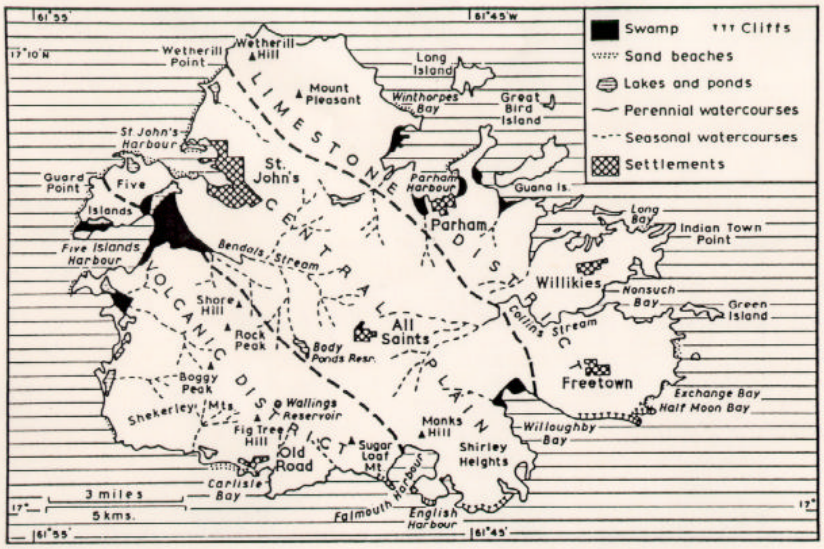

Fig. 8. Surface features of Antigua. Based on 1:25,000 topographic map, Directorate of Overseas Surveys, London, 3rd edition, 1962, and on field work. (Source: Harris 1965)

3.3.1 Telemetry

The proposed Telemetry site is leased to the USAF by the government of Antigua for use as part of the Antigua Air Station. The area is partially overgrown by brush and partially covered with grasses and is used as open pasture. The site is immediately north of an existing telemetry satiation and south of a closed runway at V.C Bird International Airport. The existing telemetry station consist of two antennae and associated operations buildings and contains full support systems such as communications, potable water, sewage treatment, and an electrical generator. The facility is used to support launches from the USAF Eastern Test Range at Cape Canaveral, Florida. The eastern boundary of the site is the North Sound, an area used intermittently by boaters. The site is served by a paved road that provides access to the U.S. Air Station to the north and the St. Johns area to the west. The road also provides access to several small boat ramps. A branch from this road bisects the site from the north to the south, connecting to the telemetry station. The USAF is planning to construct a building on this site in several years in order to consolidate some of its activities in other parts of the existing U.S. Air Station.

The largest developed areas within a radius of 1.5 miles (2.4 km) of the site include the telemetry station, V.C. Bird International Airport, Long Island (a residential area), the Antigua U.S. Air Station, an electricity generation and desalting plant, a small unnamed settlement west of the U.S. Air Station, and the Beachcomber and Sugar mill hotels.

3.3.2 Willoughby Bay Site

The Willoughby Bay Site is an undeveloped area of land leased to the VOA by the government of Antigua. Although the VOA leased the site for the purpose of establishing communications facilities, it currently has no plan for developing he site and would make it available to USAF for the proposed Starlab experiment. The site is vegetated with brush and grasses and may be used occasionally for livestock grazing. During a preliminary site visit, it was observed that the grassy portion of the site had been burned, presumably by local individuals burning wood o produce charcoal. A dirt road leads from a paved public road to the proposed site. A footpath runs from the site along the face of a cliff and ends near the shoreline at Hudson Point. Land use near the site is mostly agricultural in nature.

Populated areas near the site include the settlements of Freetown [approximately 0.9 mile (1.4 km) from the proposed site] and St. Phillips [approximately 1.3 miles (2.1 km) from the proposed site]. In addition, the Half Moon Bay and Mill Reef resorts are approximately 1.2 miles (1.9 km) and 1.8 miles (2.9 km), respectively, from the proposed site. The remaining area is rural in nature and sparsely populated. The populations of the settlement areas are not known. Along with Newfield, however, they represent the major population concentrations on the southeast side of the island. It would be expected that these areas would be occupied during the nominal engagement periods.

3.4 ECOLOGICAL RESOURCES

3.4.1 Terrestrial Resources

3.4.1.1 Vegetation

No comprehensive documentation of the flora of Antigua exists. Figure 9 shows a generalized vegetation map of Antigua. Although the Island was once heavily forested, forests now exist only in the higher and wetter southwestern part of the island. Degraded evergreen woodland exists between Non such Bay, Willoughby Bay, and Falmouth Harbor. The remainder of the Island is currently very open, with mosaic of large tracts of pasture, arable land, and shrubs. Occasional groves of trees or small coconut plantations occur throughout the area. Coastal areas characteristically contain coconut, tamarind, caesarian, sea grape, and manchineel trees, and limited areas of mangroves occur along portions of the coast. These mangroves are part of a unique plant community that has very specific requirements for growth and, hence, a limited distribution on the island. For example, the button mangrove most often occupies thedry foreshore within the reach of salt spray. Exploitation of mangroves for the production of charcoal, firewood, and poles and the destruction of shoreline habitats for human developments has raised concern about the continued existence of this unique community.

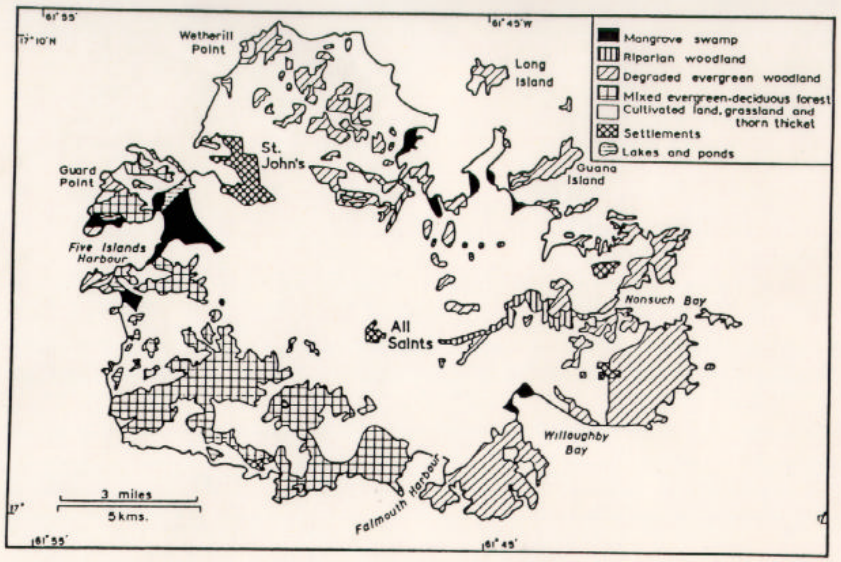

Fig. 9. Vegetation of Antigua. Generalized from aerial photographs taken in 1956 and from field work carried out in 1958 and 1960. (Source: Harris 1965)

Because grasslands represent the dominant vegetation community on the Island and occur near the alternative ground calibration sites, they will be described in more detail. The majority of the grasslands occur in the central plain; scattered mature trees give some grassland areas the appearance of savanna. In addition, there are considerable areas of upland pasture in the volcanic district as well as smaller enclosed pastures and unfenced, closely grazed "commons" throughout the island.

The most widespread native grasses are species of *Paspalum, Sprobolus, Chloris, Digitaria, Brachiaria,* and *Cenchrus*. There are also a large number of introduced grasses present, the most common of which are devil's grass, Guinea grass, goose grass, crow foot grass, Natal grass, and Antigua hay grass. Varieties of other herbaceous plants, many of which are introduced, occur in association with the grasses. Thickets of woody growth scattered throughout the grasslands consist exclusively of thorny, introduced species of Leguminosae. Most common are four species of acacia (*A. farnesiana, A. nilotica adansonii, A. tortusa, and A. macracantha*), mesquite, and logwood.

Most of the island has felt the effect of temporary worker or permanent clearing of trees for cultivation and settlement. Feral and domestic livestock, roaming uncontrolled over large areas, have had a pronounced effect on the vegetation by causing widespread damage to plants from browsing, grazing, and trampling (Harris 1965).

3.4.1.2 Fauna

The diversity of wildlife on the island is very limited, with birds being the most prominent group. A sparsely of species, especially animals, is a common characteristic of small isolated islands, such as the outer Leeward (Harris 1965). The rice rat is the only mammalian species thought to be native to Antigua. Today, no native land mammals exist on the island (Harris 1965). Several other species of rats were introduced to the island from Europe by the early colonists. In addition, the white-tailed deer from Virginia was introduced during the seventeen century as a game animal, and the northern Indian mongoose was brought to the West Indies in the 180s to destroy the introduced rats that did much damage to the sugar plantations. In the process of reducing the rat populations, however, the numbers of mongoose increased rapidly and became a serious pest before 1900. Today, the mongoose is common throughout Antigua where it has exterminated several harmless species of terrestrial lizards and snakes. Mongoose were observed at several locations on Antigua during site visits conducted in November 1988 and May 1989.

143 species of birds have been recorded on Antigua (Holland and Williams 1978). The native birds, like the land mammals, have suffered both extinction and replacement by introduced species; more species have become extinct because of man than have been introduced (Harris 1965). The mongoose has been responsible for exterminating several ground-nesting birds, notably a subspecies of burrowing owl (*Speotyto cunicularia amaura*). Other extirpated species include the roseate flamingo, a parrot (*Amazon sp.)* and Audubon's shearwater (Allen 1956; Harris 1965). The common bobwhite that was introduced, as a game bird in Antigua probably is no longer found on the island (Harris 1965). Two of the most common and conspicuous birds on the island are the bananaquit, cattle egret, Grey kingbird, brown pelican, and Carib grackle.

The only two amphibian's species that are known to have occurred in Antigua are frogs. A large edible frog (*Leptodactylus fallax*) that was introduced for its meat is no longer found on the island. The other antiguan frog, the tiny *Eleutherodactylus martinicensis*, still exists on the island quite abundant.

The reptiles of Antigua also form a relatively inconspicuous part of the fauna. Their overall numbers have been introduced to the point of extinction for some species (e.g., the endemic snake *Alsophis leucomelas Antigua*). Lizards and snakes have suffered particularly from the depredations of the mongoose. In 1964, the large edible lizard (*Iguana delicatissima*) was present on Antigua (Ethridge 1964), but sightings in recent years have been very rare (Dyde 1986).

3.4.1.3 The Telemetry site

The Telemetry site is a flat, already disturbed area near the end of a closed runway at V.C. Bird International Airport. Vegetation on the central and largest portion of this site consists of grasses (fig. 10), while typical coastal vegetation occurs along the eastern boundary. The area had been heavily grazed by cattle when it was seen during the site visits conducted in November 1988 and may 1989. The grassy area on the site also supports a large number of low-growing acacias, which are unpalatable to grazing animals. No wildlife was not observed on the site nor would any unique wildlife species be expected to occur in this area. Plant species observed near the site are listed in Table 3. A mangrove community is located along the shoreline east of the site.

3.4.1.4 The Willoughby Bay site

The Willoughby Bay site is on the southeast portion of the island in a relatively flat depression on high land (300-ft (90m) elevation) overlooking Willoughby Bay. The site is remote from large centers of population and appears to be an old field area. When the site was visited in November 1988, most of the area consisted of tall [30 in. (76 cm)] grass (Fig. 11) interspersed with patches of thorny shrubs and trees (*Acacia spp*). Observations during a second visit to the area in May 1989 indicated that the site had recently been used by charcoal burners. The grasses on the site had been burned but the shrubs and trees remained. Plant species identified near the site are listed in table 3. Vegetation at this site is much more diverse than that found on the Telemetry site. Grey kingbirds and Antillean crested hummingbirds were observed on the site and in the general vicinity during the November 1988 site visit; no other wildlife were observed at this site.

Fig. 10. View of the Telemetry site on 11/18/88.

Fig. 11. View of the Willoughby Bay site on 11/19/88.

Table 3. Plants identified at the Telemetry and Willoughby Bay sites during May 1989.

Common Name	Scientific Name	Site Names	
		Telemetry	Willoughby Bay
Cassie	*Acacia farnesiana*	X	X
Cassie, Alabama	*Acacia macracantha*	X	X
Button Mangrove	*Conocarpus erectus*	X	
Yellow balsam	*Croton balsamifera*	X	X
Pie-crust, Baylum	*Jacquinia arborea*	X	
Sailor's Broom	*Melochia tomentosa*	X	
Loblolly, Hablarliah	*Pisonia subcordata*	X	X
Cankerberry	*Solanum racemosum*	X	X
Snuff Tree	*Thespesia populnea*	X	
Dagger, Maypole	*Agrave karatto*		X
Chinkswood	*Bourreria succelenta*		X
Turpentine	*Bursera simarouba*		X
Warri bush, Nickel	*Caesalpinia bonduc*		X
Cinnamon	*Canella winterana*		X
Dul Dul, Dildo	*Cephalocereus royeni*		X
Mabi	*Colubrina arborescens*		X
Wild Tamarind	*Leucaena leucocephala*		X
White cedar	*Tabebuia pallida*		X
Tillandsia	*Tillandsia recurvata*		X

3.4.2 Aquatic Resources

Antigua is one of the islands that forms the eastern boundary of the Caribbean Sea and sits on the southern edge of a large bank of relatively shallow water. The coastline is very irregular with many refs and shoals. Endangered and threatened sea turtles are discussed in the following section.

3.4.3 Threatened and Endangered Species

Section 7 of the Endangered Species Act of 1973, as amended, does not apply to Antigua [J. Shepherd U.S Fish and Wildlife Service (USFWS), Washington, D.C. personal communication with R. Kroodsma, ORNL, October 5, 1988], and the USFWS has no records of other threatened and endangered species in Antigua. However, species listed by the USFWS that have ranges that include Antigua and that are protected under international conventions and treaties [e.g., the Convention of the international Trade in Endangered Species of Wild Fauna and Flora (CITES) and the U.S Migratory Bird Treaty] are discussed in this section.

Several Antiguan laws may be applicable to the proposed project (Sect. 5). Two of these laws were established for the protection of wildlife; (1) THE Wild Birds Protection Ordinance (CAP. 115,1913) and (2) the Turtle Ordinance (CAP. 333, 1927). These laws authorized the taking of specific wild birds and turtles during declared periods. In addition, the Wild Birds Protection Ordinance provides for the protection of specifically listed species including their nests and eggs. Included on this list are several species common throughout the island. Antigua has not signed as a member of (CITES). Several species of birds, however, are protected under the U.S Migratory Bird Treaty Act of 1918.

Four species of sea turtles that could be found in the near shore waters of Antigua: the green (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*), which are listed as threatened species by the USFWS and the hawbill (*eretochelys imbricata*) and leather back turtles (*Dermochelys coriacea*), which are listed as endangered species (Inversion 1986). There is plentiful habitat on Antigua for sea turtles to feed, rest, and nest, but the main island is not known for sea turtle nesting (IUCN 1982). Adjacent small islands such as Long Island, which is about 1.2 miles (2 kn.) across Winthorpe's Bay, may have nesting populations.

The American peregrine falcon (*Falc peregrinus anantum*), which is listed by the USFWS as endangered, was observed during the 1977 spring migration near Mill Reef, located at the southwestern end of Antigua (Holland and Williams 1978).

3.5 CULTURAL RESOURCES

Two visits were made to the Telemetry and Willoughby Bay sites to determine what cultural resources may be present and their importance. A brief examination made during the May 1989 site visit indicated that historic cultural resources are present at both potential calibration site locations and that prehistoric cultural resources are in evidence at the Telemetry site. A more systematic survey was conducted at the Telemetry site in July 1990 (Appendix A) because the initial visit revealed the potential for adverse impacts to important cultural resources. The purposes of the second visit were to obtain more information about the prehistoric and historic remains at each site and to determine the importance of the remains to the extent practicable. The July 1990 visit to the Willoughby Bay site was limited to verifying previous findings.

3.5.1 Telemetry Site

The large embossment formed by the North Sound and parham Harbor (Fig. 4) is among the more important archaeological locations in Antigua. Prehistoric a ceramic (i.e., without pottery) sites generally dating from 3000 BC to AD 1 abound all along the coasts of the harbor. Ceramic sites typically dating from AD 1 to AD 1200 are less than 5000-ft (1500 m) access the harbor. During colonial times, Parham was one of the five trading villages allowed on the island.

The reconnaissance surveys found that prehistoric and colonial remains were present throughout the site. Aloud an eroded drainage gullet, broken shell (including *Anadara notabilis, Arca zebra, Murex spp., strombus spp,. And Chama spp*.) In addition, worked flint or chert was among the densest and obvious cultural remains present. The remains, characteristics of the arsenal face of the coast along this part of Antigua, were indicative of aceramic, pre-pottery occupations. Dates of similar remains on the island range from 3000 B.C to AD 70. Adjacent to these remains, markedly different pre-historic pottery and flint were discovered in its test pits. Little or no shell was found, and pottery and flints had doubled pagination that indicated re-use of previously made tools. Notable differences in the density of remains between the two areas indicated a differential use of space.

Colonial remains were found elsewhere on the site. For instance, in a bulldozed area near the existing telemetry facility, scattered colonial ceramics were apparent and most likely associated with a cistern, which is the sole structure present. Apparently, several buildings, which were probably the remnants of the Nibb's Plantation shown on a 1749 map of Antigua, were razed during the bulldozing. In addition, remains of structure foundations and stone suitable for buildings were found scattered in cut areas within the bounds of the proposed Telemetry site. Numerous colonial ceramics, slate shingles, bricks, and bottles were discovered in widely varying densities. The different densities probably reflect living and refuse areas. Prehistoric remains, pottery, flint or chert, and shell was mixed with the colonial remains.

These remains of cultural activity on Antigua are very important archaeologically, and particularly anthropologically. Because research interests in the Lesser Antilles now focus on the interactions of peoples in the Caribbean and on settlement and migration systems, areas with sites from many different times potentially hold great significance.

3.5.2 Willoghby Bay Site

Information gathered during the May 1989 site visit suggested that the Willoughby Bay site is part of Lynch's Estate, a former sugar plantation covering much of that area. A listing of the Lynch family associated with the history of Antigua shows then a prominent colonial family. Additional evidence of colonial occupation at the site includes pottery shards that have been preliminary identified as follows: (1) white salt glazed stoneware (ca. 1720-1805), (2) creamware (ca. 1762-1820), (3) pearlware (ca. 1780-1830), and (4) earthenware (ca. 1795-1900). These materials indicate that occupation of the site could range from the early 1700s to 1900, with a median date of about 1826. The scatter and density of materials suggest that this was probably the location of peripheral plantation activity rather than the site of a manor house or other central structures. Although no indications of earlier habitation were found during the initial visit, prehistoric flints were discovered during the July 1990 visit.

The July site visit corroborated the earlier observations in that colonial ceramics were found. A mill tower and probably associated colonial buildings are located on the perimeter of the property. Immediately down the hill from the Willoughby Bay site are the remains of Fort William and one of five colonial trading villages, Bridgetown, that were present on Antigua. Bridgetown, abandoned in the 1800s, is in good condition archaeologically and currently is the object of preservation efforts undertaken by the Museum of Antigua and Barbuda. Because Bridgetown and Fort Williams are so close to the Willoughby Bay site, important historic remains are likely to be present in the area now covered by brush.

4. ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This section evaluates potential environmental impact of constructing and operating the ground calibration site on Antigua and identifies mitigate measures that would be implemented to minimize or avoid significant impacts on the environment.

4.2 EFFECTS OF LASERS

4.2.1 Potential Human Health and Safety Concerns

For the purpose of this EA, safety concerns for lasers at AMOS and the Starlab are confined to potential eye or skin injuries from exposure to laser radiation in excess of defined maximum permissible exposure (MPE) limits. Potentially, exposed persons may be on the ground, at sea, or in aircraft.

To illustrate the type of analyses performed for the SWAT and RME and to facilitate the understanding of important points about Starlab laser illumination of the ground surface, simplified calculations are provided in Appendix F of the Starlab Program EA (USAF 1990). The illuminator and marker lasers on Starlab are used as examples. These examples use basic trigonometric relationships in conjunction with safety guidelines and regulations [Air Force Occupational, Safety, and Health Standard (AFOSH) 161-10 (USAF 1980), ANSI (1986), and IRPA (1984)].

An examination of the general nature of laser hazards for laser systems that would be used in the Starlab experiment has been made [see Appendix F (USAF 1990)]. The results suggest that, using generally accepted methods described in IRPA (1984), ANSI (1986), and AFOSH 161-10 (USAF 1980), laser hazards exist for humans in several situations. Because of safety systems and planning, however, no situation has been identified for which the unaided eye would experience an overexposure either at the surface of the earth or in aircraft. For example, assuming an 8X light gathering power for a binocular that might be used to view the illuminator laser, a rectangular zone roughly 125x 225 ft (40 x 70 m) centered on the calibration site target exceeds the ANSI MPE for human eye. This target zone would be protected, however, with physical boundaries [i.e., a 6-ft (1.8-m) fence]. Thus, inadvertent intruders would be prohibited from entering the illumination zone. Higher power optical devices could be used just outside the target zone with a result in exceedenences of appropriate standards. The outer boundary of the calibration sites, roughly 3000 x 7600-ft (900 x 2300 m), would be posted with temporary signs and roadblocks to prevent unauthorized entrance. Thus, all persons who might attempt to enter the sites for naked eye or optical aided viewing would be prevented from doing so. Even with the most powerful devices available to the public, viewing the weak “edges” of the footprint outside of the calibration sites would not result in exposure of exceedence levels.

Potential health and environmental effects at ground calibration sites are discussed further in Sect. 4.6. Additional, specific discussions of potential laser hazards and incident scenarios are presented based on the material developed in Appendix F of this document and in detailed safety analyses prepared on the Starlab program [PEP-20 (LMSC) 1989]

Most human experience with light is with conventional light sources that radiate isotropically (i.e., in every direction) or in slightly focused beams (e.g., as in automobile headlights). For traditional beam sources, the light beam spreads out rather rapidly with distance. Hence, a high-beam car headlight can temporarily blind a person even if the person is many feet from the center of the road. Laser light beams do not spread like conventional light sources.

If a viewer (e.g., an amateur astronomer) is not directly in the “footprint” looking “up the beam,” the beam is essentially invisible.

The presence of the laser beam may be detected from light scattered when it passes through air containing dust or moisture particles, as observed during laser light shows. With scattered light from these laser beams, one literally sees the path of the laser. The scattered light from the Starlab lasers would be so weak that, even with a high magnification, the intensity would be reduced by factors of thousands to millions from the actual footprint and no eye hazard could exist from this scattered light. Likewise, light potentially reflected from a variety of unintended surfaces (i.e., in the case of misalignment or other error) would be degraded in reflection could be viewed for mor5e than one pulse of 25 nanoseconds and would, therefore, not result in any exceedence of the exposure guidelines.

A detailed accident analysis is contained in the Payload Hazard Report [PEP-20 (LMSC 1989)] entitled "Inadvertent Exposure of Public or Orbiting Satellites to Laser Radiation." The scenario for the calibration sites includes persons using binoculars and postulates three levels of failure. The probability of a person seeing one pulse was estimated to be about 1 x 10^-9. This level of failure is so small and the duration of exposure is so short that the hazard is considered negligible.

4.2.2 Potential Laser Effects on Wildlife

Wildlife could be exposed to a laser beam in three ways: (1) birds could fly through a beam aimed from the shuttle to earth, (2) birds could fly through a beam aimed from earth to the shuttle, or (3) a beam from the shuttle could accidentally wander off the target or be misdirected to areas inhabited by terrestrial or marine wildlife (e.g., nesting areas).

In the most serious case that would result in maximum potential effect, an animal would be within a stationary laser beam, look directly at the laser source with both eyes, and have both eyes in focus on the source (exception the case of birds that can look directly at an object with only one eye). In the most serious case for animals, a portion of the laser beam would be focused to a point on each eye's retinal fovea, which is the most important area of the retina for vision. When the light energy of the laser beam is focused to a manner, the energy is concentrated, and damage due to thermal heating of the retina or a photochemical change in the retina is most likely to occur (in the same way that a magnifying glass can be used to focus light energy from the sun to produce a hot spot) (Swope 1969). Damage to the fovea for whatever reason could result in a severe visual handicap. If the eye is not focused on the laser source, the light energy will not be focused to a point on the retina but would be spread out over a larger area of the retina and would not be as likely to cause damage. Also, if the eye is pointed somewhere off to the side rather than directly at the source, any damage to the retina would be outside the fovea and would be less likely to produce severe visual handicap.

Many bird species (hawks, eagles, terns, and swallows) have two foveae in each eye one central fovea for monocular vision and one lateral fovea believed to be important for binocular vision (Sillman 1973, Martin 1985). Because no bird can point both eyes simultaneously, which prevents binocular vision? It is believed, however, that a bird's lateral foveae may be located such that light rays from a source may be focused on both simultaneously, thus allowing binocular vision. If these beliefs lateral foveae could be damaged simultaneously by a powerful laser beam if the bird were within the beam looking with both eyes toward the beam source.

If a bird were to fly through a laser beam pointed from the shuttle to a target on the ground, it would be exposed to the beam probably for no more than 5 to 7 s (depending on the diameter of the beam and the speed at which the bird is flying). It is highly unlikely that the bird would be looking at the laser as it entered the beam because the laser light source on the shuttle (as well as a laser source at an earth-based station) could not be seen or detected prior to entering the beam. Only a bird within the beam that is looking into the exit lens and deep into the apparatus where the laser is located could see the laser light source itself. For a bird outside the laser beam on earth, no point of light due to operation of the laser would be visible on the shuttle. Once a bird is within the laser beam, some time would pass before the bird could detect and focus on the laser source. Therefore, the time of eye exposure would be less than the time it looks for the bird to fly through the beam.

An accidentally misdirected laser beam from the shuttle would have virtually no potential for impact on any moving or stationary individual animal, either on land or in the sea. The light energy would be reduced (i.e., less concentrated) and would be less able to cause injury because the beam's width would increase as it approached the earth's surface. For example, the beam from the red marker laser used in the SWAT experiment would be at least four orders of magnitude below the MPE of 2.5 mW/cm^2 and would have no adverse effect on any exposed animal, either moving or nesting. The reflected beam from the blue laser in the SWAT experiment would be even less powerful than the marker laser and no impact would, therefore, be expected. Exposure to the beam would extremely short due to the rapidly with which the beam would swing past the animal or would be shut off. There would be virtually no opportunity for the animal to look directly at the beam and focus its eyes on the laser.

Although the sensitivity of birds' eyes to bright light is not known, the literature indicates that the visual physiology of birds is generally not greatly different from that of humans. For example, maximum image brightness on the retina is very similar in the diurnal pigeon, the nocturnal Tawny owl, humans, and other mammals, and varies by little more than sixfold across a wide range of other nocturnal and diurnal vertebrate species (Martin 1985). Thus, optical functions (as opposed to cell functions) of the avian eye are apparently incapable of gathering and focusing light to a significantly greater degree than those of the human eye, and the avian retina would not be subjected to significantly greater concentration of light energy and thermal heating. The remaining question is whether the cells and structures of the avian eye are more susceptible to photochemical damage than those of the human eye (i.e., damage caused by chemical changes due to bright light rather than thermal effects). Although information to answer this question is lacking, available literature shows no reason to expect that avian cells involved in vision are much more sensitive than those of humans are.

Evaluation of eye damage to a human viewing a shuttle laser source from within the beam indicates that such damage could occur only in binoculars were being used to look directly up the beam towards the source (Sect. 4.2.1). The objective lenses of the binoculars are larger than the unaided eye, thus presenting greater potential for eye damage. Without the binocular light gathering effect, it is considered highly unlikely that any damage could occur to the eyes of humans, other mammals, or birds exposed to a laser beam from Starlab.

4.3 IMPACTS ON LAND USE

4.3.1 Telemetry Site

Impacts on land use from construction at the Telemetry site would be temporary in nature and small in scope. Installation of a scoreboard, light array, and associate structures at the proposed site is in keeping with its existing land use and would remove only a small area from grazing or other productive uses. Less than 1 acre (0.4 ha) of land would be within the security fence (Fig. 5) and an additional few acres currently used for cattle grazing also would be affected by the location of support facilities. In addition, all equipment and associated structures installed or the ground calibration engagements would be removed after the experiment was completed so that construction impacts would be limited in duration. Before construction would be iniated, ETR would review local land-use restrictions that guide or restrict development for the site and resolve any conflicts with local authorities.

The only facility that is likely to have people in the immediate area during the ground calibration experiments is the U.S. Air Station would be operational during the engagements. Populated areas in the immediate vicinity of the calibration site used during daytime are expected to be uninhabited at night when the ground calibration experiments occur. Settlements, hotels, and motels that are located approximately 2 miles (3.2 km) to the west and north of the U.S. Air Station would be occupied during the engagement period. The population of nearby residential areas is estimated to be under 300 (based on approximately 50 houses counted in the settlement and an estimated maximum household size of six persons). To prevent people in these areas from approaching the Telemetry site, the paved road that services the area would be closed and road blocks would be set up at those points where the roads cross the outer boundary of the calibration site (Fig. 7) prior to calibration engagements (Sect. 2.1.4). These measures would make viewing of the laser beam by casual observers highly unlikely. Closing the paved road could temporarily reduce access to the water by boaters and nearby businesses. Because restrictions would occur primarily at night, there would be only limited impacts during the day, when boaters and businesses might be affected. Impacts from restricting access would be minimal because the road would be open to all traffic except during periods just prior to, during, and immediately after a ground calibration engagement period of about 45 min. Daytime traffic would proceed in a normal fashion, without interference. Night traffic virtually is nonexistent.

Impacts on land use from operations at the proposed Telemetry site would be minor, if mitigated as discussed below. Most of the impacts would result from restricting access to areas near the site and from possible operational conflicts with V.C. Bird International Airport and other nearby facilities could occur; curtailing or modifying operations at these facilities during ground calibration engagements are being considered as part of the overall safety planning for these engagements. Any interference should be minimal because the experiments would occur in the middle of the night when the airport is normally not being operating. ETR staff would consult with operators of these facilities to ensure that no conflicts arise.

Impacts on land use would be mitigated to an acceptable level by restoring the site after operations were concluded, minimizing access restrictions, and coordinating operations with local officials and the management of nearby facilities. Following the completion the proposed action, all structures and equipment used during the proposed action would be removed from the site. After removal of these materials, all trash would be taken from the area and properly disposed, and any disturbed areas would be restores to their original conditions.

4.3.2 Willoughby Bay Site

Although the WilloughbyBay site is isolated from nearby population centers, a misdirected laser beam has the potential to cross over English Harbor. It impossible that people on the yachts in the harbor would be awake in the middle of the night (the time when the calibration experiments would be conducted) and would have high-powered binoculars readily available. In addition, the yachts themselves have extensive areas of highly polished woodwork that could possibly deflect laser light to houses on the hills surrounding the harbor. Viewing such deflected laser beams, however, would not have a significant adverse impact on the observer because of the low energy of any such beams (Sect. 4.2.1).

The impacts on land use from construction of the proposed action at Willoughby Bay would be similar to those described for the Telemetry site, except that construction would involve a relatively undisturbed site. In addition, construction would temporarily restrict use of a trail through the site.

Impacts on land use from operations would temporary and minor. They would consist of temporarily restricting access to the area until after the completion of the engagements. Impacts on surroundings areas would be less than those described for the Telemetry site due to the rural nature of the area.

Impacts on land use would be mitigated to an acceptable level by rehabilitating the site after the engagements are completed and by minimizing, access restrictions. Following the completion if the proposed action, all structures and equipment used during the proposed action would be removed from the site. After removal, all trash would be taken from the area and properly disposed, and any disturbed areas would be rehabilitated to their original condition.

From logistics standpoint, use of this site is less desirable than for the Telemetry site because its relatively remote location requires more support equipment, including a 100-ft (30-m) microwave tower to communicate with the U.S. Air Station about 9 miles (14 km) northwest of the site. In addition, transport and installation of equipment at this site would require portions of the existing access rod to be cleared and widened and shrubs/trees to be removed from the target area. By contrast, the Telemetry site would require very little, if any, clearing. The public cannot be restricted easily from the Willoughby Bay site.

4.4 IMPACTS ON ECOLOGICAL RESOURCES

4.4.1 Terrestrial Resources

4.4.1.1 Telemetry site

As described in Sect 3.3, this site is a flat, already disturbed area near the end of an old unused runway of V.C Bird International Airport. The largest and central portion of this site currently is covered with grasses used for cattle grazing; the surrounding land contains shrubs and small trees typical of coastal areas on the island. Establishment of the ground calibration facilities at this site (Sect 2.1.4) would be unlikely to result in significant effects to the ecological resources of the area. The land is relatively flat and would require little, if any, grading. The security fence to be constructed around the scoreboard and light assembly pads (Fig.5) would encompass less than 1 acre (0.4 ha). Necessary support structures for the experiment would be located on nearby land already disturbed by USAF operations. With the site being close to the USAF station, communications requirements for the experiment could be satisfied easily without additional construction or disruption of habitat. No wildlife would be expected to be affected by installation of the necessary facilities. The primary ecological resource of concern at this site is the mangrove community near the shoreline east of the site. In order to protect this resource, all construction and operational activities at this site would be restricted to the grasslands and other areas already disturbed.

Impacts on wildlife from conducting the calibration experiment are not expected to be significant because the area supports very little wildlife. Activation of the lighting system would be likely to cause any birds or other wildlife in the immediate vicinity of the site to leave the area temporarily. However, most wildlife that might be active at the time of the night when the calibration is conducted. If any wildlife were to be exposed to the laser beam, it is highly unlikely that any adverse impact would occur (Sect 4.2.2).

4.4.1.2 Willoughby Bay site

Use of this site for the ground calibration engagement would require clearing approximately 0.2 mile (0.3 km) of dirt road overgrown with brush and grass. In order to get the equipment to the site, portions of the road would need to be widened and leveled. The site itself [0.6 acres (0.2 ha)] and additional land for laydown of construction materials and placement of operations trailers would need to be cleared. Habitat at the site is somewhat unique with respect to the surrounding land in that it consist of tall grasses interspersed with patches of thorny shrubs and trees. Noise associated with construction activities would be a temporary disturbance to wildlife. Once the project was completed and the structure was removed, the plant and animal communities would re-establish themselves.

Use of this site would require construction of a 100-ft (30-m) microwave communications tower to relay signals from the onsite equipment to the USAF Station. Although the exact location and land area needed for this tower have not yet been determined, construction of this site structure would result in additional land disturbance. Land would need to be cleared to transport the tower equipment to its site, and positioning of the guy wires for the tower would disturb some additional vegetation. Additional evaluation of the impacts associated with construction of this tower would be needed if this site were to be chosen for development.

Impacts on wildlife from conducting the calibration experiment would not be expected to be significant. Animals in the vicinity the site would normally not be active at the time of night when the calibration experiment would occur. Activation of the lightening system is likely to cause any birds or other wildlife in the immediate vicinity to leave the area temporarily. Therefore, it is unlikely that any wildlife would be present in the immediate area during transmission of the laser beam. If any wildlife is exposed to the laser beam, it is highly unlikely that a damage would result (Sect. 4.2.2).

4.4.2 Aquatic Resources

No aquatic resources would be affected by the Starlab experiment at either site. The Willoughby Bay site is not near water, and no streams, ponds or other water bodies occur on the site itself.

4.4.3 Threatened and Endangered Species

There is no turtle-nesting habitat near the Telemetry or Willoughby Bay sites. The beaches adjacent to the telemetry site are limited to only a few feet of muddy substrate that is exposed at low tide. Any threatened or endangered turtles or marine mammals that might be inadvertently exposed to a misdirected laser by being in the water adjacent to the site would not be harmed. There is no evidence that the visual sensitivity to light of these animals approaches a level equal to a factor of 64 greater than the human eye. This is the minimum magnification of the laser that would be required to cause possible damage to the human eye. Hatchlings that enter Winthrope Bay from nearby beaches (e.g., those on Long Island, Fig. 4) could be temporarily disoriented if a large amount of indirect light is emitted from the Telemetry site. Lights of the proper wattage and distance from the ground [e.g., as defined in Appendix H of the Starlab EA (NSAF 1990a) for launch Complex 20 at Cape Canaveral Air force Station] would be used to mitigate any possible impact should the experiment occur during the turtle nesting season.

The American peregrine falcon, an U.S. federally listed endangered bird, has been observed offshore, near the southeastern end of Antigua (Sect 3.4.3). Although this species could be present in the general area during spring migration, it would be unlikely to be affected by the proposed project. Even if the falcon were to fly into the laser beam, it is unlikely that any damage would result (Sect 4.2.2).

4.5 IMPACTS ON CULTURAL RESOURCES

4.5.1 Telemetry Site

Information obtained during May 1989 and July 1990 site visits to the Telemetry site indicates that important prehistoric cultural resources are present on the site (Sect. 3.5.1; Appendix A). Impacts on these resources would be reduced to an acceptable level by adopting the mitigate measures discussed below. Although some of the site already has been disturbed by earth moving the past, it is possible that activities associated particularly with constructing and dismantling the calibration facility could adversely affect significant archaeological and historic resources. Definitive statements about the levels of impact are not yet possible because the exact location of calibration site facilities an equipment has not yet been delineated; the location of these would determine what resources might be affected. Construction of the proposed project would include building fences, clearing brush, limited excavation (e.g., possible leveling of the site for the concrete pads and transportation of materials by heavy trucks. Dismantling could involve some limited earth moving to remove the calibration pad, fences, and other temporary structures or equipment to restore the site as well as truck movement on the site. In addition, personnel working on the site could remove or disturb archaeological and historic remains.

Impacts or archaeological and historic resources from the calibration experiment itself should be minimal and limited to any disturbance of archaeological remains that would be caused by activities of onsite personnel.

To avoid significance impacts from constructing, operating, or dismantling the facility on archaeological resources, several mitigation measures would be taken (sect. 2.1.5). First, the exact location of the calibration pad would be determined in consultation with a qualified archaeologist to avoid adverse impacts to important remains to the extent practicable. Second, during construction activities such as clearing, post-hole digging for the fence, and excavation, a qualified archaeologist or cultural resource expert would be on site to monitor any archaeologist or historic remains uncovered. Third, if such remains were determined to preserve prehistoric and historic cultural resources. Fourth, throughout these procedures, there will be consultation with the Antiguan government and local experts to ensure compliance with local laws and regulations.

4.5.2 Willoughby Bay site

Observations made during the May 1989 and July 1990 site visits at the Willoughby Bay site indicate that potentially important historic cultural resources are present (sect. 3.5.2). Potential affects to thee resources could be reduced to an acceptable level by adopting the mitigate measures discussed above for the Telemetry site. Impacts on archaeological and historic resources from the calibration experiment itself should be minimal and limited to any disturbance of archaeological remains that would be caused by activities of onsite personnel. Archaeologist conducting the July 1990 surveys of both potential sites concluded that, from the standpoint of cultural resources, the Telemetry site is preferred because it has already been disturbed (Appendix A). In contrast, because the Willoughby Bay site has experienced relatively little such disturbance, impacts from project activities could be more severe (Appendix A; personal communication between C.A. Hoffman, Northern Arizona State University and A. K. Wolf, ORNL, August 6, 1990).

4.6 IMPACTS ON HUMAN HEALTH AND SAFTEY

Under operating plans, no human exposure to laser light is likely to occur. However, laser light exposure to humans at Ascension Island could occur as a result of an unplanned situation. Under no circumstance could an overexposure take place for the unaided eye, but if the laser light were to be viewed directly “up the beam” towards the source with 8X binoculars, the MPE could be exceeded by a factor of approximately four.

The planned illumination of the calibration site on Ascension Island by the illuminating laser board the Starlab is limited to a rectangular area about 125 x 225 ft (40 x 70 m) centered on the target. Because this area is not accessible to the public, an examination was made for occurrences that could result in the light path crossing unrestricted areas. The practical possibilities described in PEP-20 (LMSC 1989) are limited to:

- Premature operation of laser systems
- Inadvertent operation of laser systems
- Malfunction or unplanned operation of laser systems (the laser pointing outside of planned Illumination zone).

Premature or advertent operation of the illuminator laser could occur from electrical failure software/firmware programming error mechanical failure or operator error. In order to ensure lasers would not lase in an unplanned manner controls have been developed for times before the engagement and after the engagement.

Prior to an engagement deliberate payload crew actions would be required to open protective enclosure doors turn on the illuminator laser electronics turn on the illuminator laser pump; enable the illuminator laser mechanical shutter to be opened and software command the illuminator to lase. The timing of these events would be controlled by a detailed procedural plan. After an engagement, a software timer closes the shutter and turns off the laser. The payload crew would manually command the shutters closed and turn off electrical power to the laser. Software would also close the laser shutter if the target moved out of the coarse tracker.

To ensure that the illuminator laser would not mispoint outside of the planned illumination zones restrictive provisions have been made. An automatic software shutoff would close the illuminator if the laser mispoints. A backup to this automatic shutoff would be provided so the payload crew could monitor the target on the video monitor showing the coarse tracker. If the target image moved off the coarse tracker, the crew could manually close the illuminator laser shutter. The Space Test Objects engagement (Table 2) and the ground calibration. Experiments (Sect. 2.1.3.3) would be performed before the Starbird engagements in order to determine that the illuminator laser was properly boresighted.

Given the safeguards built into the laser and its pointing system the minor size of the illumination zone and the fact that the laser beams are only hazardous if illumination is directly viewed using optical assistance, the likelihood of harm coming to any individual would be remote.

4.7 CUMULATIVE IMPACTS

No significant adverse cumulative impacts are anticipated from the Starlab program. The only possible cumulative effects from exposure to laser light would be by repeated exposure of the eye or skin to beams of greater intensity than the respective MPEs for these organs. There would be a maximum of three engagements at each of the ground calibration sites. Exposure is precluded by operational parameters.

The development of a ground calibration site on Antigua would disturb small areas of land, therefore, add an increment of disturbance to that already created by other USAF activities in these areas. No unique or legally protected species or ecological resources are likely to be significantly affected by the proposed action. Impacts of constructing and operating the ground calibration facilities would involve minor disturbance to the surface and could affect historic and archaeological resources present on the site. However, with recommended mitigation (Sect. 2.1.5), such disturbance should be limited in extent and insignificant. The ground calibration site facilities are temporary and would be removed upon completion of the Starlab experiments.

As a separate action, the ETR plans to build a new building on the Telemetry site in the future. A result, an additional incremental impact on the archaeological and historical resources at the Telemetry site could occur. The impacts from a new ETR building would be more permanent than those from the Starlab site construction and could involve greater disturbance to resources on the site. The USAF intends to implement adequate mitigation to avoid disturbing any important historic and prehistoric cultural resources discovered on the site. If disturbance cannot be avoided, the USAF would institute survey and/or salvage programs to document, and possibly recover and preserve, any important historic or archaeological resources. Mitigation plans and consultation with local government officials will be discussed in a separate environmental review document being prepared for the proposed new building.

5. CONSULTATION AND COORDINATION

Construction and operation activities in Antigua would comply with relevant U.S. environmental statues and regulations with existing treaty agreements with the government of Antigua. Antigua has not signed as a member of CITES, but several species of birds are protected under the U.S Migratory Bird Treaty Act of 1918. Compliance with all local laws and regulations of Antigua required by the existing treaty with that government would be done. The following local environmental laws have been identified that may be pertinent to the proposed action:

1. The Forest Ordinance (CAP.99, 1941) and associated regulations provide for the protection of Lands that were forested at the tie of enactment, prevention of their deforestation where determined
   Necessary by the Antiguan government.

2. Two Laws have been established for the protection of wildlife: (1) the Wild Birds Protection Ordinance (CAP. 115, 1913) and (2) the turtle Ordinance (CAP. 333, 1927). These laws authorize the taking of specific wild birds and turtles during declared periods. In addition, the Wild Birds Protection Ordinance provides for the protection of specifically listed species including their nets and eggs. Included on this is several species common throughout the island.

3. The National Parks Act of 1984 and subsequent amendments established a National Parks Authority to preserve protects, manage, and develop natural physical and ecological resources and the cultural heritage of Antigua and Barbuda. Only one national park has been established to date; Nelson's Dockyard National Park, which includes the historic restoration of English Harbor, as well as surrounding marine and terrestrial natural areas and several rural settlements.

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September 1990

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September 1990

APPENDIX A

PAHSE II ARCHAEOLOGICAL SURVEYS

OF PROPOSED GROUND CALIBRATION SITES

ON ANTIGUA, West Indies

PHASE II ARCHAEOLOGICAL SURVEYS
PF PROPOSED GROUND CALIBRATION SITE
ON ANTIGUA, WEST INDIES

By

Bruce K. Nodine

Prepared For

Starlab Program, United States Air Force

Contract #F04701-90—07

Charles A. Hoffman

Principle Investigator

14 August 1990

Report of Phase II Archaeological Survey

Starlab Program, Antigua

Introduction

This report deals with archaeological manifestations investigated and recorded in a cultural resource survey of a proposed ground calibration site on the Island of Antigua, West Indies. Tow sites were investigated, a primary, and secondary, proposed location for the project.

Antigua is a small island in the eastern West Indies, being about 1300 miles (2100 km) east-southeast of Miami, Florida and 300 miles (474 k) east-southeast of San Juan, Puerto Rico (figure 1). One of the Leeward Islands at the northern end of the Lesser Antilles, it is located along the northeastern edge of the Caribbean Sea (17° to 17°10′ north latitude and 61°40′ to 61°55′ west longitude). The Island is roughly circular in outline (figure 2), covering about 108-sq. mi. (280 km^2); it is approximately 14X11m (22x17km)-east west and north south.

A need had been established to conduct archaeological surveys for prehistoric and historic cultural resources at the calibration site, near the U.S Air Force Station, just south of Barnacle Point, on the north coast of Antigua. Barnacle Point lies at the north end of a spit of land that projects easterly into North Sound (Figure 3) and forms the north flank of a large embayment, part of which is called Parham Harbour. The area surveyed was part of an old U.S. Army Base and is now under the jurisdiction of the U.S. Air Force Station. It lies very close (a few meters) to the landing strip for planes flying into and leaving the island. This is proposed as a primary site for the ground calibration station.

An alternate site is located on land under the jurisdiction of the Voice of America, along the north coast of Willoughby Bay on the southeast coast of Antigua. Both the Air Force Station and the voice America area were to be surveyed for cultural resources, which might be adversely affected by construction of the proposed ground calibration site.

The Maps

Four maps were supplied for this survey. The primary map is section 2294SE, taken from the Directorate of Overseas Surveys (D.O.S. 1970). The coordinates of the southwest corner of this section are 17ºnorth latitude and 61º46′27. 66″west longitude. This map shows 100-m horizontal grids and 10-ft contours. Although this map is significantly out-dated, each of the maps supplied used it as the base map.

Figure 1. Antigua is an island east-southeast of Miami, Florida, at the northern end of the Lesser Antilles.

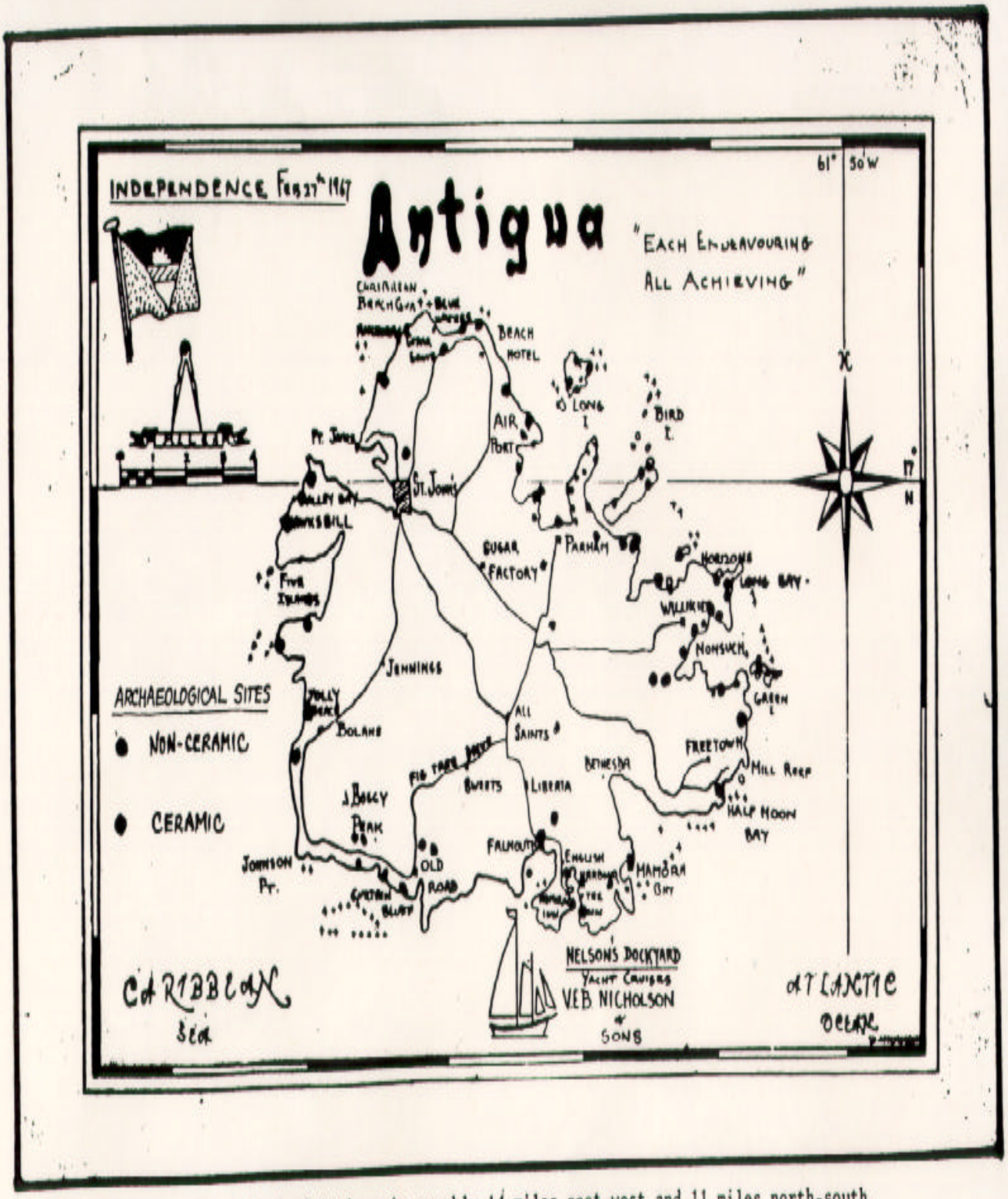
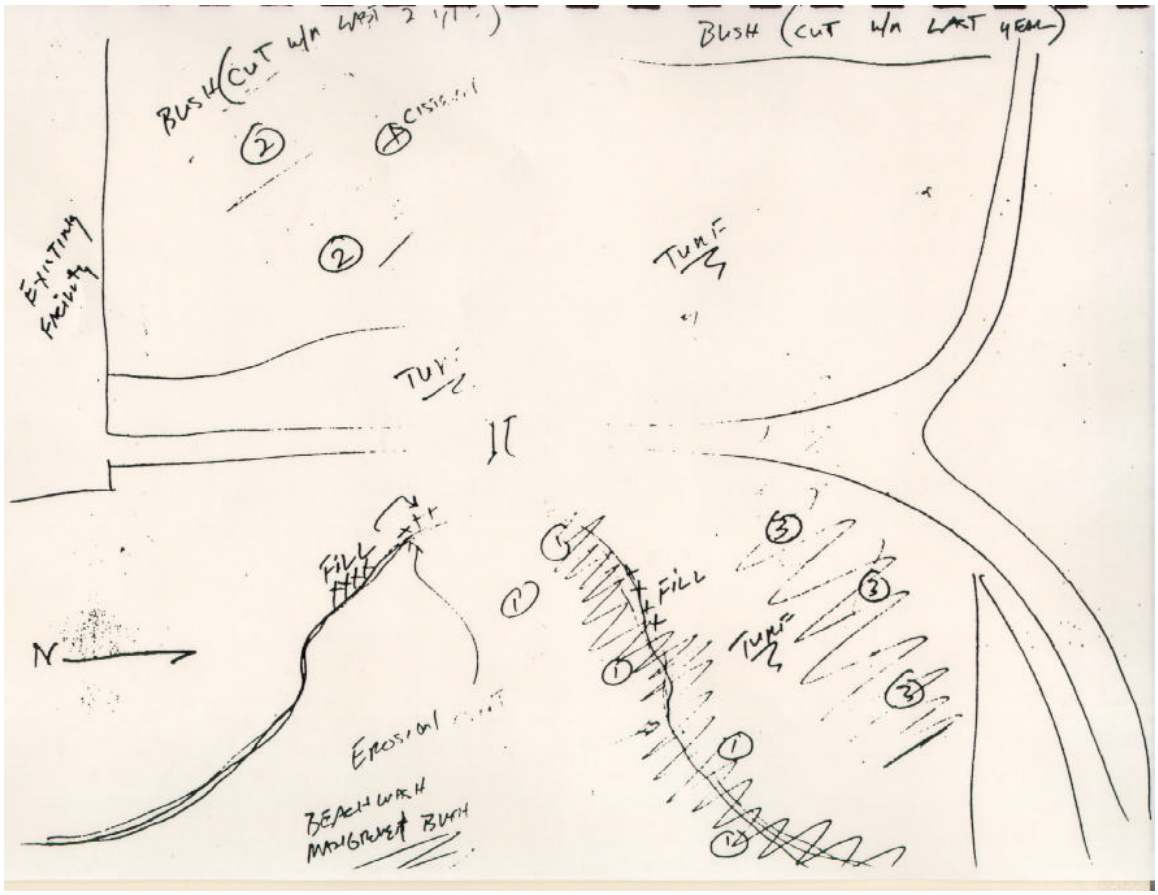


Figure 2. The Island of Antigua is roughly 14 miles east-west and 11 miles north-south. The primary location for the ground calibration satation is near the Airport on the north coast of the Island.

Figure 3. The proposed ground calibration site lies just south of Barnacle Point on a spit of land that projects easterly into North Sound and Parham Harbour.


BUSH (CUT W/N LAST YEAR)
BUSH (CUT W/N LAST YEAR)
EXISTING FACILITY
TURF
TURF
FILL
FILL
TURF
N
EROSION
BEACH WORK
MANGROVE BUSH

The first map supplied is simply a photocopy of the D.O.S. map with the "calibration site" penned in. On this map, the calibration site is generally centered in the space between the existing telemetry facility and the main road. The access road to the existing facility bisects the proposed calibration site.

The second map supplied is titled "Antigua" in the upper right hand corner are the numbers ORNL-DWG 89M-14162. This map portrays the calibration site much closer to the edge of the land (as represented on the D.O.S. map). The horizontal scale of the reduced D.O.S map is approximately 550 ft to 1 1/8 inches.

The scale of the calibration site per se is approximately 300 ft to 1 ¼ inches. The scale of the trench that will be excavated, from the "operation center" (block house) 35200J, marked "ground distance 550 ft" is approximately 550 ft to 1 ¼ inches.

The next map supplied is titled, "Cal Site Layout Telemetry Site, Antigua." In the upper right hand corner is "Lockheed LMSC-F269537," and in the lower right hand corner is K9-7034/024. Three different scales are used on the map.

Precise location of the proposed calibration site was impossible based on these maps; different representations of the proposed site complicated the situation since the data on which each is based (the D.O.S. map) are 22 years old. *

Site Area

During recent years, there has been headward erosion on the drainage ditch in the property (Map titled "Antigua" ORNL-DWG 89M-14162). Half way between the main road and the existing telemetry facility the 10-ft contour crosses and re-crosses the access road, inditing the lowest point of the road. Centered between the contour at this lowest point, a culvert passes under the road.

It appears that over half of the proposed calibration site will be in the wetlands/mangrove area, or in the sea, depending upon which scale on the maps one uses. If the scale of the "ground distance 550ft" is used, the "Beacon Lamp Array" per se would be very near, or in, the sea.

To accurately portray the location of archaeological remains in the area, I produced a "place map" with visually estimated contours". The remains discussed below are indicated on this map. Most of the remains are visible on the surface; in the areas where "turf" is marked, a series of shovel test pits was required as the surface below the turf was not visible (figure 4).

The Remains

The cement pad, or proposed calibration site, per se is represented on maps as being located ion a drainage gully on the site. That area is differential from surrounding ground by a 3 to 10 ft drop or erosion face. Archaeological remains are evident all along this cut, marked with #1 in the pace map.

*The problem with the maps identified in this report will be dealt with by laying out the site in consolation with an archaeologist to avoid disturbing any significant remains.

In the bottom of the gulley, the base matrix of the area is revealed as white, lime-rich marl. The archaeological remains are contained in the dark soil from the ground surface to about 50-cm below surface, where dark soil and white marl interface. These remains consist mostly of broken shell (including Anadara notabilis, Arca zebra, Murex sp., Stombus sp., Chama sp., etc.) and worked flint or chert. The area contains some of the most dense and obvious cultural remains on the property surveyed, however, it is (or was) characteristic of the erosion face of the whole coast along this part of the Island.

From initial survey, cultural remains are taken to be aceramic. That is, prehistoric pottery was not found in the area. Moreover, worked flint tools, usually indicative of pre-pottery occupations, are numerous. The occupations on Antigua have returned dates ranging from 3000 B.C to A.D 70 (e.g. JO-9 Five Islands: 1`90 B.C.-A.D 70; PH-33 Birgits: 3363 B.C.-2705 BC B. K. Nodine 1990).

The area bulldozed about two years ago (I visited the site in 1988, just after the clearing) is the area downhill from the existing telemetry sites and is indicated as #2 on the pace map. In this area, large trees have been uprooted and piled. Colonial ceramics are scattered in the area. These are most likely associated with the cistern, the sole structure still standing. From the quantity of stone in the area, it appears that several buildings were razed during the bulldozing. These remains are probably the remnants of the Nibb's Plantation shown on the 1749 Map of Antigua (published according to Act of Parliament on February 2, 1749; Robert Baker, Surveyor).

Another area of remains is presently a mown grass area on either side of the access road to the present telemetry facility. This area is indicated as #3 on the pace map. Initial surface surveys found no cultural remains, however, test pits in the area returned prehistoric pottery and flint. Although adjacent to the cultural remains discussed in Area #1 (the shell and flint area); these remains are markedly different. Area #3 contains little or no shell; at the same time, we found pottery and flints that have double patination indicating reuse of previously made tools. There are marked differences in the density of the remains, indicating differential use of space.

There appear to be the remains of structure foundations and stone suitable for buildings scattered in the cut areas. Colonial ceramics abound as well as slate shingles, bricks, and bottles. The density of these remains varies greatly, probably indicating living and refuse areas. Prehistoric remains, pottery, flint or chert, and shell is mixed with the colonial remains.

Discussion

The proposed site for this facility is on the western shore of North Sound (Parham Harbor) on the north coast of Antigua (Figure 3). This large embayment, combining North Sound and Parham Harbor, is one of the more important archaeological locations on the Island. Aceramic sites

(Generally from about 3000 B.C to AD 1) abound all along the coast of this Harbor. Ceramic sites (generally from AD 1 to AD 1200), such as the Large Blackman Point site, are less than 5000 feet across the Harbor.

During colonial times, Parham was one of the five trading villages allowed on Antigua. Fort Byam was on Barnacle Point, 1200 ft from the proposed site for the ground calibration facility. The Nibb's Plantation was on the site (at the cistern), St. George's Church and several other plantations were located at the vicinity of the proposed project.

These remains of cultural activity on Antigua are very important archaeologically, and particularly anthropologically. Research interests in the Lesser Antilles have moved to addressing the interaction of peoples in the Caribbean as well as searching for settlement and nigration systems. Hence, areas with many sites from many different times are very important.

One of the early potential interactions is indicated by the proximity of aceramic (generally considered pre- or before ceramic) remains and ceramic remains. During the last five years, research has uncovered aceramic remains, which return dates more regularly, associated with ceramic occupations. Further ceramics remains have been dated to the first few centuries BC (Nodine 1987-1990).

Another presently important issue in Caribbean archaeology is the possible interaction between the so-called Carib and Arawak Indians. These interactions would have occurred in the period just before historic times. At issue is the degree to which the Caribs and Arawaks differ. Tradition considers the Arawaks as peaceful, horticultural society, the Caribs as cannibalistic and warlike.

Presently, some Caribbean scholars consider the two "tribes" to be more a manifestation of early explorers' inaccurate accounts of the people they encountered, rather than a difference that is archaeologically or linguistically visible.

Another interaction requiring attention is the relationship between the plantation on the site and the site of Fort Byam (destroyed), only 1200 feet away.

We can also investigate how different societies utilized similar environments differently. It appears, for instance, that the ceramic remains on the property are located along the erosional cut; ceramic remains are located a little farther back; colonial remains, and prehistoric ceramics, occur on the hillocks.

This is an important aspect; the site of Nonesuch Bay on the East Coast of Antigua contains extensive remains of what is most likely an agricultural/settlement area (Davis and Nodine excavation 1987/8). The topography and soils at the Telemetry site are strikingly similar to the Nonesuch Bay site area.

The alternate proposed ground calibration site is located on property under the jurisdiction of the Voice of American (VOA) on the north coast of Willoughby Bay on the East Coast of Antigua. This site is presently heavily wooded and very difficult to access. Survey of the property consisted of walking paths crossing the land. On these transects, several colonial ceramics were found as well as prehistoric flints (figure five).

While these remains are generally expected and found on all parts of the island, an important point is that there is a mill tower and probably associated colonial buildings on the perimeter of the property.

Immediately down the hill from the VOA site are the remains of Fort William and Bridgetown. As mentioned earlier concerning Parham, Bridgetown was also one of the five trading villages allowed on Antigua during colonial times. Bridgetown is the trading village in the best condition archaeologically as it was abandoned in the 1800s andlies in ruins today. The museum of Antigua and Barbuda is taking stepped to preserve these remains.

With Bridgetown and Fort Williams proximate, significant historic remains are expected in the site presently covered in bush.

Recommendations

The first task is for a team of surveyors to create an accurate map of the property showing the proposed ground calibration facility and its general impact area, and then to indicate on the ground where the site is to be located. In terms of archaeological materials, 15 ft would shift the facility from dense to less dense remains.

We cannot assess what would actually be required to mitigate the loss before construction until the precise location of the facility is known. The property has archaeological remains all over it. Mitigation strategy and time required could only be estimated once we know which archaeological remains will be adversely impacted.

If excavation and removal of the remains is not an option, an archaeologists should definitely be on site to monitor any clearing for the site, the fence-post-hole digging, and the excavation of the 550-ft trench from the control center to the calibration site.

References Cited

NODINE, B.K.

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1990. _____. Abstracts. Annual meeting, Society for American Archaeology. Las Vegas.

Figure 5. The Voice of America alternate ground calibration site is on the north coast of Willoughby Bay on the southeast coast of the Island of Antigua.

APPENDIX A

PHASE II ARCHAEOLOGICAL SURVEYS

OF PROPOSED GROUND CALIBRATION SITE

NEAR THE U.S. AIR FORCE STATION ON ANTIGUA< West Indies

REPORT OF CHARLES A. HOFFMAN VISIT, JULY 1990

(Contract #F04701-90-M-0077)

On July 1990 I flew to Antigua, West Indies, to review an archaeological survey for the United States Air Force by Mr. Bruce K. Nodine, and to prepare myself to review Mr. Nodine's final report of prehistoric and historic archaeological resources that might be adversely affected by construction of a ground calibration site near the U.S. Air Force Station on that Island.

Mr. Nodine met me at the airport. We proceeded immediately to the proposed ground calibration site near Barnacle Point, although we did not conduct a foot-survey at that time. The area earmarked for construction is proposed to be about 300 ft by 125 ft; the overall area that might be adversely impacted, slightly larger. This rectangular space lies in a roughly northwest-southeast orientation (see attached sketch map). It is on a slope, the higher ground being to the southwest. The sea is eroding the northeast corner. A fenced-in "yard" containing several large telemetry dishes overlaps the proposed site along its southern edge.

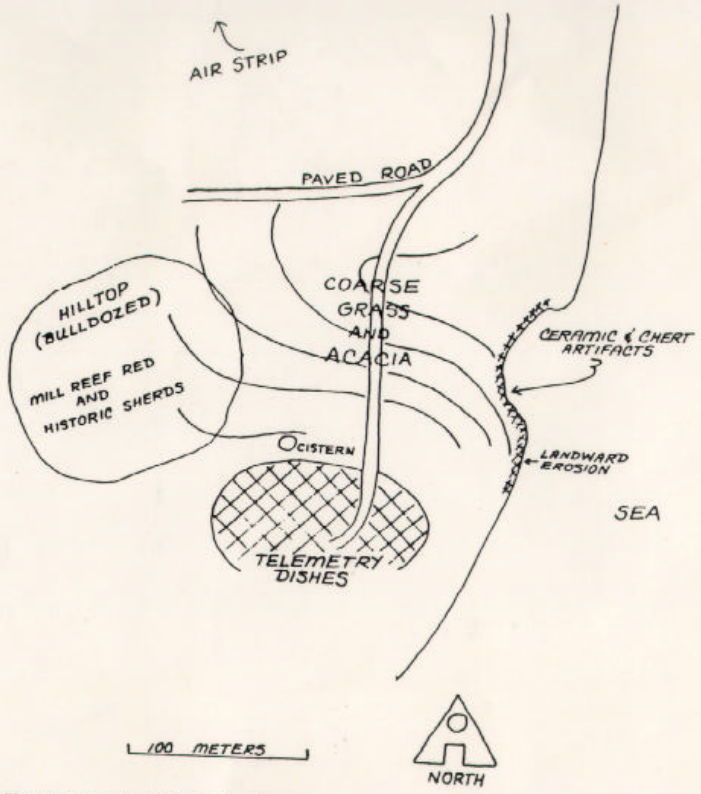
The next morning, 19 July 1990, Mr. Nodine and I visited a Mr. Tim T. DeGrave, Antigua Air Force Station Base Manager. We informed him of our purpose, and of our intentions to conduct both a feet survey that day, and minor archaeological testing a few days later. We described the vehicle we would be using and asked that Base Security be informed of our purpose. Mr. DeGrave responded in the affirmative.

Later that day, Mr. Nodine and I attempted a foot survey of a point of land south of Barnacle Point where the proposed ground calibration activity is scheduled to be placed. Several problems became immediately apparent.

1. The actual location for the proposed ground calibration site was not clearly marked either on the ground or on the maps provided;

2. It would appear that the maps provided are slightly dated, in as much as the sea has eroded away some of the easterly edge of the land proposed for the calibration site;

3. Evidence of both prehistoric and historic use was found over much of the proposed site area, and



Photocopy of Field Sketch Map. Hoffman visit, 20 July 1990.

4. Considerable disturbance had already taken place.

Mr. Nodine's subsequent investigations bear our in detail each of the above problems.

At higher, southwest, end of the rectangle, the hilltop had been bulldozed, apparently within the last year. Sparse vegetation, recently returning, permitted us to note both prehistoric (Mill Reef Red) and historic (ca. 1780 to 1820) postsherds, broken historic tiles, and other evidence of human occupation or use. We also found broken shell and chert fragments there.

Below the hilltop, to the east and along the southwest corner of the rectangular, considerable debris had been bulldozed into piles. I could not determine when this had taken place, although Mr. Nodine suggested that he might have witnessed the bulldozing a few years ago. There, I found an intact cistern, apparently part of a house, mill, or other multiple activity sites.

North of the cistern area, the slope is covered in coarse low-growing Acacia. It appeared that the soil covering had been removed, or that fresh, marly, soil had been brought in on top, many years ago, and the grass and Acacia covering came in and is now kept in check by frequent mowing. It appeared un-natural. I saw little evidence of human occupation or use on the surface in this area. I did note a single crab or rodent hole in which dark soil, typical of an occupation area, had been covered with marl.

The wave cut bench or terrace is at the East End of the rectangle. A2 to 3m drop-off marks where the sea had eroded landward. In the exposed edge, we noted a several-centimeter-thick lens of dark Grey soil lying on top of a white sand and limestone base. Either in that Grey lens, or eroding out, we found two potsherds that may date post AD 1100, considerable worked and utilized chert, chert cores, and shell fragments. Much of the shell may be natural, storm wash, to the area, but it was obvious that the area was at one time an important lithic site.

On 20 July 1990, Mr. Nodine and I visited the "VOA" site on the north shore of Willoughby Bay. "Shore" is actually not an appropriate term. The north side of Willoughby is a rather steep face dropping rapidly from about 300ft above sea level to the beach below. Again, we did not have precise location information for the VOA proposed alternate site. We had traveled to the settlement surrounding St. Phillips church and on to the east on the main road. About 2km or less past St. Phillips we found a track road leading off to the right, south, toward an abandoned sugar mill. We understood the mill is either on or adjacent to the proposed alternate site. We followed the track road on foot, noting moderate to slight distribution of historic potsherds. The area is presently heavily wooded, however, I visited the site in 1961 and at that time, it was completely exposed as a recently cutover sugar cane field.

All of the VOA site is, of course, up on “top”. None of it, to my knowledge is over the edge of the drop off. The “top” is composed of gently rolling limestone hills of the Antigua Formation. I understand that the VOA alternate site was the location of a major sugar-milling complex, not far from the historic settlement of Willoughby, and an important coastal town of Fort William. Should the VOA site be chosen for location o the ground calibration site, a thorough survey, and possible mitigation, should be in order.

On the morning of 21 July 1990, I departed for the United States.

In sum, I spent two days on Antigua visiting proposed sites for a ground calibration station. One site is at the U.S. Air Force Station on the north coast of the Island, the alternate, at VOA land on the southeast coast. In both instances, precise locating of the proposed site was impossible. At the Air Force station site, I noted evidence of prehistoric and historic use of the site area. At the VOA, I noted evidence of important historic use. At the Air Force Station, it appeared that the land had already been disturbed, perhaps over many years as the United States has maintained military facilities there for much of this Century.

Mr. Nodine and I discussed the alternate sites and their relative problems and good points. We concluded, tentatively, that the Air Force Station site might be preferable, pending, however, information obtained during test excavations there.

Charles A. Hoffman
Principal Investigator